

“EXPERIMENTAL AND ANALYTICAL STUDY OF FLEXURAL BEHAVIOUR OF RC BEAM USING POLYPROYLENE AND CARBON FIBRE REINFORCED CONCRETE”

Submitted in partial fulfilment of the requirements for the award of
Master of Engineering Degree in Structural Engineering

by

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**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND
ENVIRONMENT**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade “A” by NAAC

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APRIL - 2021



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of K SANDHIYA (39380008) who carried out the project entitled “**EXPERIMENTAL AND ANALYTICAL STUDY OF FLEXURAL BEHAVIOUR OF RC BEAM USING POLYPROYLENE AND CARBON FIBRE REINFORCED CONCRETE**” under my supervision from November 2020 to April 2021

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DECLARATION

I **K SANDHIYA** hereby declare that the Project Report entitled "**EXPERIMENTAL AND ANALYTICAL STUDY OF FLEXURAL BEHAVIOUR OF RC BEAM USING POLYPROYLENE AND CARBON FIBRE REINFORCED CONCRETE**" done by me under the guidance of **DR.R.PADMA PRIYA** at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** is submitted in partial fulfilment of the requirements for the award of Masters of Engineering degree in Structural Engineering.

A handwritten signature in black ink, reading "K. Sandhya", is positioned above the signature line.

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SIGNATURE OF THE CANDIDATE

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully.

I am grateful to them. I convey my thanks to **Dr. DEVYANI GANGOPADHYAY., B.Arch., M.T.P., Ph.D.**, Dean, School of Building and Environment and **Dr. S. Packialakshmi., M.E., Ph.D.** and **Dr. R. PADMAPRIYA, M.E., Ph.D.** Head of the Department, Dept. of Civil for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide **Dr.R.Padma Priya., M.E., Ph.D** for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of Civil who were helpful in many ways for the completion of the project.

Abstract

The most widely utilized “manmade” material globally for construction in many developing countries in all types of civil engineering works is “CONCRETE”. The presence of micro cracks at mortar aggregate interface is the weakness of concrete. The addition of fibers in the concrete has been come in to practice to overcome the existing problems. The fibers are added in fiber reinforced concrete, concrete mix to improve the concrete properties in all directions and that the discontinuous fibers will be uniformly distributed in the mix. In this research paper, an attempt is made by only using the fibers. The experimental investigation were done by casting the specimens, 150x150x150mm, cube, 150mmx300mm, cylindrical, 100mmx100mmx500mm prism, for testing the compressive strength, split tensile strength, flexural strength, and Beam also casted for testing flexural behaviour (230mmx230mmx1500mm) with and without fiber. The strength and durability properties are carried out for various mix designations and compared with normal conventional concrete. In present project work M25 grade considered and the polypropylene (PP) fiber at 0.5, 1, 1.5, 2 and 2.5% volume fractions and carbon fibers at 1, 1.5, 2, 2.5 and 3% volume fractions are introduced into fiber-reinforced. Based on the results will find the superior crack resistance, improved tensile strength. The proposed sample will be tested at 7 days, 14 days and 28 days age of curing. These results will show whether the FRC is suitable for proper confinement or not for structures subject to extreme load conditions.

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CHAPTER-1

INTRODUCTION

1.1 General

Concrete is weak in tension. Micro-cracks begin to generate in the matrix of a structural element at about 10 to 15% of the ultimate load, propagating into macro-cracks at 25 to 30% of the ultimate load. Consequently, plain concrete members cannot be expected to sustain large transverse loading without the addition of continuous bar reinforcing elements in the tensile zone of supported members such as beams or slabs.

The developing micro cracking and macro cracking, however, still cannot be arrested or slowed by the sole use of continuous reinforcement. The function of such reinforcement is to replace the function of the tensile zone of a section and assume the tension equilibrium force in the section.

The addition of randomly spaced discontinuous fiber elements should aid in arresting the development or propagation of the micro cracks that are known to generate at the early stages of loading history. Although fibers have been used to reinforce brittle materials such as concrete since time immemorial, newly developed fibers have been used extensively worldwide in the past three decades.

Different types are commercially available, such as steel, glass, polypropylene, or graphite. They have proven that they can improve the mechanical properties of the concrete, both as a structure and a material, not as a replacement for continuous-bar reinforcement when it is needed but in addition to it.

The introduction of fiber additions to concrete in the early 1900s was aimed primarily at enhancing the tensile strength of concrete. As is well known, the tensile strength is 8 to 14% of the compressive strength of normal concretes with resulting cracking at low stress levels.

Such a weakness is partially overcome by the addition of reinforcing bars, which can be either steel or fiberglass, as main continuous reinforcement in beams and one-way and two-way structural slabs or slabs on grade (Nawy and Neuwirth, 1977; Nawy et al., 1971). They are able to add to the stiffness and crack-control performance by preventing the micro cracks from

propagating and widening and also by increasing ductility due to their energy-absorption capacity.

Common applications of fiber-reinforced concrete include overlays in bridge decks, industrial floors, shotcrete applications, high-way and airport pavements, thin-shell structures, seismic- and explosion- resisting structures, super flat surface slabs on grade in warehouses, and for the reduction of expansion joints. It describes the geometry and mechanical properties of various types of fibers that can be used as randomly dispersed filaments in a concrete matrix.

Because of the wide range of properties for each type of fiber, the designer should be guided by the manufacturer's data on each product and experience with it before a fiber type is selected.

1.2 Concrete

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape. It is readily available in urban area at relatively low cost. Concrete is strong under compression yet weak under tension and a relatively brittle material. As such, a form of reinforcement is needed. The most common type of concrete reinforcement is via steel bars.

The advantages to using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life. The disadvantages to using concrete include poor tensile strength, and form work requirement.

1.3 Reinforced Concrete

Tensile strength of concrete is typically 8% to 15% of its compressive strength. This weakness has been dealt with over many decades by using a system of reinforcing bars (rebars) to create reinforced concrete; so that concrete primarily resists compressive stresses and steel bars resist tensile and shear stresses.

The longitudinal rebar in a beam resists flexural (tensile stress) whereas the stirrups, wrapped around the longitudinal bar, resist shear stresses. In a column, vertical bars resist compression and buckling stresses while ties resist shear and provide confinement to vertical bars.

Use of reinforced concrete makes for a good composite material with extensive applications. Steel bars, however, reinforce concrete against tension only locally. Cracks in reinforced concrete members extend freely until encountering a rebar. The need for multidirectional and closely spaced reinforcement for concrete arises.

1.4 Fiber Reinforced Concrete

Concrete is well known as a brittle material when subjected to normal stresses and impact loading, especially, with its tensile strength being just one bar to withstand tensile stresses, to compensate for the lack of ductility and is also adopted to overcome high potential tensile stresses and shear stresses at critical location in a concrete member.

Even though the addition of steel reinforcement significantly increases the strength of the concrete, the development of micro-cracks must be controlled to produce concrete with homogenous tensile properties. The introduction of fibers was brought into consideration, as a solution to develop concrete with enhanced flexural and tensile strength, which is a new form of binder that could combine Portland cement in bonding with cement matrices.

Fibers are generally discontinuous, randomly distributed throughout the cement matrices. Referring to the American Concrete Institute (ACI) committee 544, in fiber reinforced concrete there are four categories namely

CFRC - Carbon Fiber Reinforced Concrete

PPFRC – Polypropylene Fiber Reinforced Concrete

SNFRC - Synthetic Fiber Reinforced Concrete

NFRC - Natural Fiber Reinforced Concrete

Fiber Reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete with discontinuous, discrete, uniformly dispersed suitable fibers. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibers

Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus

reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete.

The amount of fibers added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibers) termed volume fraction (V_f). V_f typically ranges from 1% to 3%. Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fiber is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Fibers which are too long tend to “ball” in the mix and create workability problems.

1.4.1 Carbon Fiber Reinforced Concrete

- Concrete reinforced with carbon fibre.
- Highly stressable lightweight material
- Combines concrete and carbon fibres
- Higher strength than steel with quarter of its weight.

Carbon fibres have been under continuous development for the last 50 years. Composed of carbon atoms bonded together to form a long chain. Thin strands of carbon atomic structure of carbon fibre is similar to the graphite, consisting of sheets of carbon atoms arranged in a regular hexagonal pattern, only difference is being the way sheets interlocks.

Carbon fibers are the most common fibers used in concrete. They may be smooth or deformed in a variety of ways to improve the mechanical bond with concrete. Carbon fibers have high modulus of elasticity which is 10 times that of concrete, reasonably good bond and high elongation at fracture. Carbon fibers range in length from 0.25 inches to 3.0 inches. Fiber concentrations in concrete mixes generally range from 0.1 % to 1 % by volume.

Present applications of carbon fiber reinforced concrete with and without normal reinforcement have been in the areas of refractories, pavements, overlays, patching, hydraulic structures, thin shells, and armour for jetties, rock slope stabilization, mine tunnel linings, and precast products. Addition of carbon fibers does significantly increase compressive strength and it increases the tensile toughness, and ductility. It also increases the ability to withstand stresses after significant cracking (damage tolerance) and shear resistance.



Fig 1.1: Carbon Fiber

1.4.2.Polypropylene fibre

Polypropylene is one of the cheapest and abundantly available polymers. Polypropylene fibers are resistant to most chemical attacks. Its melting point is high (about 165degrees centigrade). So that it can withstand a working temp, as (100 degree centigrade) for short periods without detriment to fiber properties.

polypropylene fibers exist in reasonably large quantities in many countries of the world. There are many types of natural fibers such as Sisal, cellulose, and jute. Although, historically, straw fibers have been used to reinforce adobe, little scientific effort has yet been devoted to the use of natural fibers as reinforcement for various building materials. Coconut fibers are very durable under natural weathering conditions and attempts have, therefore, been made to include them in cement-based materials.

But they have some disadvantages in that the elastic modulus is very low and they are sensitive to moisture changes. Natural fibers are lighter in weight and may be more chemically inert than either steel or glass fibers. They also are more economical. However, these fibers produce lower bond and lower modulus of elasticity than mineral or metallic fibers.

Therefore, most of these fibers cannot increase the strength of the composite material and may indeed reduce it. In addition, natural fibers may cause

some durability problems.



Fig 1.2: Polypropylene Fiber

PROPORTION OF FIBRE:

Concrete fiber composites are concrete elements made from a mixture comprised of hydraulic cements, fine and coarse aggregates, pozzolanic cementitious materials, admixtures commonly used with conventional concrete, and a dispersion of discontinuous, small fibers made from steel, glass, organic polymers, or graphite. The fibers could also be vegetable fibers such as sisal or jute. Generally, if the fibers are made from carbon, pp, the fiber length varies from 0.5 to 2.5 in. (12.7 to 63.5 mm).

They can be round, produced by cutting or chopping wire, or they can be flat, typically having cross-sections 0.006 to 0.016 in. (0.15 to 0.41 mm) in thickness and 0.01 to 0.035 in. (0.25–0.90 mm) in width and produced by shearing sheets or flattening wire. The most common diameters of the round wires are in the range of 0.017 to 0.040 in. (0.45 to 1.0 mm) (ACI Committee 544, 1988, 1993, 1996). The wires are usually crimped or deformed or have small heads on them for better bond within the matrix, and some are crescent shaped in cross-section.

The fiber content in a mixture where steel fibers are used usually varies from 0.25 to 2% by volume—namely, from 20 to 165 kg/m³. A fiber content of 30 to 40 kg/m³ is common in lightly loaded slabs on grade, precast elements, and

composite steel deck topping. The upper end of the range, more difficult to apply, is used for security applications such as vaults, safes, and impact-resisting structures.

APPLICATION

The uses of FRC over the past thirty years have been so varied and so wide spread, that it is difficult to categorize them. The most common applications are pavements, tunnel linings, pavements and slabs, shotcrete and now shotcrete also containing silica fume, airport pavements, bridge deck slab repairs, and so on.

There has also been some recent experimental work on roller-compacted concrete (RCC) reinforced with fibers. The list is endless, apparently limited only by the ingenuity of the engineers involved. The fibers themselves are, unfortunately, relatively expensive; a 1% carbon fiber addition will approximately double the material costs of the concrete, and this has tended to limit the use of FRC to special applications.

- i. Slab on Grade: All types of pavements and overlays, industrial floors, roads, taxiways, hangars, etc.
- ii. Structural Concrete: Foundations (deep and shallow), machine foundation, slabs, column beams and lintel, bridge decks and girders etc.
- iii. Water retaining Structures: RCC retaining walls, water tanks, cross drains, swimming pools, hydel projects, check dams, canal lining, ETPs, jetties, ports, spillways etc.
- iv. Water proofing in rooftops, sunken toilets, etc.

i) Advantages & Disadvantages

i. Advantage:

- Improve structural strength.
- Reduce steel reinforcement requirements.
- Improve ductility.
- Reduces cracks, thus improving durability.
- Low Maintenance Cost.

ii. Disadvantage:

The use of FRC, being a relatively new technology poses a threat of a high initial cost of construction

NEED FOR STUDY:

- Light weight – increasing the strength and life span of the concrete
- Cracking control
- Decrease of water permeability
- Increases fire resistance
- Reduce plastic shrinkage
- Low thermal expansion

CHAPTER-2

LITERATUREREVIEW

2.1 GENERAL:

Introducing fibre reinforced concrete phenomenon in this industry has extensive results in increasing the strength of concrete. The use of fibres offers cost education, energy savings, arguably superior products, and minimize the hazards in the environment. Usage of such products also changes the microstructure of the composition by participating in the hydraulic reactions.

The main purpose of literature review is to give an idea about the research work conducted in the world. This forms the basis on which one can carry out the work and techniques that can be used for conducting experiments. The following literature review elaborates the research studies made on addition of fibre in concrete.

2.2 LITERATURE REVIEW:

Bhaskar Dhiman et.al,(2020) reviewed attempts to study various applications and future trends of CFRP for structural applications worldwide. Through literature, we found CFRP significantly increases the life of structures, strengthened infrastructure, and minimized the maintenance requirements. Discrepancy related to tensile and compressive strengths of CFs observed in a significant amount. Therefore, integrated efforts may be used in the CFRP area to reduce the existing gap between theoretical and practically calculated tensile strengths, and work should be done to improve the compressive behavior of carbon fibers.

Ehsan Mohseni et.al,(2018) investigated the physical and mechanical properties of polypropylene fiber-reinforced lightweight geo polymer concretes are assessed. Geopolymer synthesis consists of rice husk ash and nano-alumina as solid precursors and sodium hydroxide and sodium silicate with a ratio of 2.5 as alkaline solution. nano-alumina amount is 20% of total volume of the binder for all mixtures. Scoria particles are used as lightweight aggregates (LWA) with replacement ratio of 0, 10 and 20% by volume of the total aggregates. Polypropylene (PP) fibers is added to the mixture with the amount of 0, 0.5 and 1% by the volume of the binder. Compressive and flexural strength, density, water absorption and rapid chloride permeability test (RCPT) were evaluated. Results

indicated that PP fibers improves the mechanical properties (especially flexural strength) while incorporation of LWA reduced the compressive and flexural strength slightly. Water absorption of geopolymer samples decreased by the incorporation of PP fibers which can compensate significantly the negative impact of LWA replacement. Replacement of 10% LWA does not have significant impact on water absorption and chloride permeability of composites; however, 20% replacement reduced durability. Finally concluded lightweight geo polymer concrete would be suitable for structural applications due to its relatively low density, high compressive strength and good flexural strength, which is improved by adding PP fibers.

Netragaonkar et.al,(2019) investigated the mechanical properties of hybrid fiber reinforced concrete. Where the fibers used were consists of nylon fiber and carbon fiber. For this purpose four mixes are done. One normal concrete mix and three hybrid fiber reinforced concrete mixes were prepared. The nylon fiber of various ratio are 0.25%, 0.5%, 0.75% and carbon fiber of various ratio are 0.1%, 0.2%, 0.3% are mixed on volume of concrete. The concrete mix design is used as per IS: 10262-2009 in M30 grade. Total percentage of Fiber are 0.35%, 0.7%, 1.05%. Slump test was carried out for each mix in the fresh state in order todetermine the workability of the hybrid fiber reinforced concrete. From the slump test all specimens show low workability. 3.8% increase in the compressive strength of the Hybrid Fiber Reinforced Concrete (HYFRC), 1.6% increase in the tensile strength of the HYFRC, and 31% increase in flexural strength of HYFRC.

Ajeethkumar et.al,(2017) carried out the experimental study in the behavior of polypropylene fiber reinforced concrete. The polypropylene fibers were mixed into the concrete in the form of reinforcement into the concrete with uniform orientation of the fibers. The tests on the concrete were conducted before and after by adding polypropylene fibers into the concrete in different contents, i.e., 1.6%, 1.7%, 1.8% of the cement mass. It was observed that the composite with 1.6% of polypropylene fiber demonstrated the highest compressive, flexural and split tensile strengths when compared to the other contents of fibers. The optimum result acquired Fiber reinforced concrete is fixed to accomplish additional flexure strength in the concrete beam.

Rakesh Sakale et al., (2015) described, Storage and safe disposal of waste & crushed glass is a huge problem for our urban & rural areas in India. Everywhere reuse of waste glass eliminates or consumption this problem. In this experimental work, the effect of partially replacing of glass powder in concrete is studied. The cement in concrete is replaced by waste glass powder in steps of 10% 20%, 30%& 40% respectively by volume of cement and its effects on compressive strength, split tensile strength, workability and flexural strength are determined. It is found that the compressive, flexural and split tensile strengths of concrete increase initially as the replacement percentage of cement by glass powder increases become maximum at about 20% and later decrease. The workability of concrete reduces monotonically as the replacement percentage of cement by glass powder increases. The replacement of cement up to about 20% by glass powder can be done without sacrificing the compressivestrength.

Rishabh Kashyap et al., (2013) described, Due to pozzolanic reactivity, Rice Husk Ash is used as a supplementary cementing material in concrete. It has economical and technical advantages to be used in concrete. I am going to partially replace cement by the use of RHA by 5%, 10% & 15% & 20% by weight of cement in four different experiment to find out the maximum strength and compare it with the strength of normal concrete by using the grade of M30 at the days of 7days,14days&28 days. This research therefore is an investigation of the performance of the concrete made of partially replacing OPC with RHA on the structural integrity and properties of RHAconcrete.

OBILADE, I.O. et al., (2014) described, this paper summarizes the research work on the properties of Rice Husk Ash (RHA) when used as partial replacement for Ordinary Portland Cement (OPC) in concrete. OPC was replaced with RHA by weight at 0%, 5%, 10%, 15%, 20% and 25%. 0% replacement served as the control. Compacting factor test was carried out on fresh concrete while Compressive Strength test was carried out on hardened 150mm concrete cubes after 7, 14 and 28 days curing in water. The results revealed that the Compacting

factor decreased as the percentage replacement of OPC with RHA increased. The compressive strength of the hardened concrete also decreased with increasing OPC replacement with RHA. It is recommended that further studies be carried out to gather more facts about the suitability of partial replacement of OPC with RHA in concrete.

Pandit Upendra Mahendra et.al,(2016) Conducted the experimental study of CFRP & GFRP strengthened reinforced concrete Beam in Flexure & Shear, total 9 no. of reinforced concrete beams were casted. M25 grade of concrete mix is used for beams. Carbon Fiber Reinforced Polymer (CFRP) and Glass Fiber Reinforced Polymer (GFRP) were used for strengthening the beam which were procured from Fosroc Constructive solution. CFRP and GFRP were applied in different configuration in flexure and shear on that beam using epoxy primer and saturant. The main objective of this paper is to present the optimized technique for strengthening the Reinforced concrete beam in shear and flexure using CFRP and GFRP with suitable pattern of wrapping the beam. To enable guidelines for future design recommendation. Beams were tested under 4 point bending load. Based on the results different comparisons were made and it was found that beam strengthen with CFRP show better result than GFRP.

Divya et.al,(2018) investigated the additional strength given to the concrete by using admixtures. Concrete materials involve ingredients like cement, coarse aggregate, water, admixtures like fly ash, ground granulated blast furnace slag (GGBS). Coarse aggregate of size 12mm is used. The M53 grade of cement is tested for the process of construction purpose and future use. finally concluded that from the result, the mix proportions 1:4 gives more compressive It is clearly seen from the experimental result that Pervious Concrete has very low Compressive Strength, Split Tensile Strength as well as Flexural Strength. The admixture has to be added to increase the strength of Pervious Concrete in future work. And fly ash, GGBS values strength of 20% increases. Then the optimum percentage of fly ash and GGBS are to put together the strength has to be found. The flexural behavior have to be found for the strength of pervious concrete. The bond will be reduced in pervious concrete. The reinforcement is given with cement paste to increase the bond and also protect it from rusting for future work.

Deore et.al,(2017) conducted experimental investigation was performed to evaluate the strength of concrete, in which natural sand was partially replaced with waste foundry sand (WFS). Percentages of fibers were added with respect to weight of cement. Tests were performed for 30% replacement of sand by WFS with various percentages (0.25%, 0.50%, 0.75% and 1.0%) of carbon fiber for M30 grade concrete at different curing periods (3, 14 and 28 days). The maximum flexural strength 6.05 Mpa (3 days), 7.35 Mpa (14 days), 9.05 Mpa(28 days) were obtain at 30% replacement of sand by WFS with 0.75% carbon fiber addition in concrete. The optimal use of 30% WFS with 0.75% carbon fiber has a better mechanical property. The crack formation is very small in fiber specimen compare to the non fiber specimens. Higher amount carbon fiber decreases the bonding in the concrete with results in strength degradation.

Yasir Khan et.al,(2019) investigated focused on strength, durability properties of concrete by addition of various fibers with different dosages. The optimality and effect of fibers on concrete properties are studied and behavior of concrete is experimentally verified by casting cubes, cylinders and beam specimen. Studies have shown that the addition of steel fibers in a concrete matrix in proves all the mechanical properties of concrete, especially tensile strength, impact length and toughness. The resulting material possesses higher compressive, tensile strength and better ductility. The Mechanical properties such as compressive strength, tensile strength, toughness, impact, flexural etc. are greatly influenced by addition of fibers, optimum dosage of fibers governs these properties and must carry out optimality study on various fibers. The Type of fibers, selection of fibers, properties like length, diameter aspect ratio, its effect on properties of concrete changes with addition of dosage. The prime importance must be given for selection of fiber, its type etc. The Various fiber used in concrete significantly improves many properties of concrete. The combination of fibers thus shows advanced improvement and great changes in properties of concrete. The Addition of fibers with additional supplementary cementations material such as fly ash, silica fumes etc. should better performance by improving workability of concrete and inherent properties of concrete.

2.3 SUMMARY:

The literature available on fibre reinforced concrete plated reinforced

concrete beams provides ample information on the load-deflection behaviour and study parameters included strength, deflection and ductility of reinforced concrete beams. Most researchers proposed models for reinforced concrete beams strengthened. Some researchers presented mathematical modeling for predicting the study parameters of fibre reinforced concrete strengthened reinforced concrete structural members. Few researchers conducted reliability analysis fibre reinforced concrete strengthened concrete beams. there have been enormous numbers of studies on beams with hence, further research is necessary to understand the interaction between the load carrying capacity, deflection and ductility of fibre reinforced concrete strengthened reinforced concrete beams.

- FRC incorporated specimen increases the life of structure.
- It minimize the maintenance requirements.
- It increases the strength.
- Material consumption is reduced.
- Economical section when compared to conventional concrete.
- Improve the performance of workability.
- FRC incorporated concrete has high performance in all aspects when compared to conventional concrete.

CHAPTER-3

SCOPE AND OBJECTIVE

AIM:

- To determine the flexural behaviour of reinforced concrete beam using polypropylene and carbon fibre reinforced concrete.
- To determine optimum mix ratio of fibres in concrete by adding it with suitable concrete ingredients.

OBJECTIVE:

- To determine the mechanical properties of the concrete. such as compressive strength, flexural strength, split tensile, water absorption, acid attack, alkali attack
- To determine the optimum percentage of addition of fibres based on compressive strength
- To determine the flexural behaviour of RC beam experimentally
- To determine the flexural behaviour of RC beam analytically
- Comparison of experimental and analytical results.

SCOPE OF THE STUDY:

In this study, the properties of fresh and hardened concrete of M25 grade by addition of fibres, by-product materials produced from the process of manufacturing coal, plastic. The Carbon fibre and polypropylene fibre will be incorporated in the present study and characteristic will be evaluated. In present work the polypropylene (PP) fiber at 0.5,1 ,1.5 ,2 and 2.5% volume fractions and carbon fibers at 1, 1.5, 2,2.5 and 3% volume fractions are incorporated into fiber-reinforced concrete.

CHAPTER-4

MATERIALS AND METHODOLOGY

4.1 MATERIALS:

4.1.1 Cement

Cement has different properties and characteristics which depend upon their chemical compositions. By changing in fineness of grinding, oxide compositions cement has exhibit different properties and different kind of cement. The use of additives, changing chemical composition, and use of different raw materials have resulted the availability of many types of cements. Cement used in the experimental work is ORDINARY PORTLAND CEMENT of 43 grades.

The results of the tests on sample are listed

Table 4.1 Tests on cement

1.	specific gravity	3.15
2.	standard consistency	32%
3.	Setting time	
	(i) Initial setting time	345 minutes
	(ii) Final setting time	510 minutes
4.	Fineness	3%

4.1.2 Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. The fact that the aggregates occupy 70-80 percent of volume of concrete, it has some impact on various characteristics and properties of concrete. Earlier, aggregates were considered as chemically inert material but now it has been recognized that some of the aggregate are chemical active and also certain aggregates exhibit chemical bond at the interface of aggregate and paste.

4.1.2.1 Coarse Aggregates

Crushed granite of 10mm & 20mm size are used as coarse aggregate. In the present investigation, locally available crushed blue granite stone aggregate of size 20mm and down, is used and the various tests, carried out on the aggregate

are given below. The following tests are conducted in accordance with IS standards.

The results of tests on coarse aggregate is given in table

Table 4.2 Tests on Coarse aggregate

1.	Fineness modulus	7.12
2.	Specific gravity	2.85
3.	Water absorption	0.3%

4.1.2.2 Fine Aggregates

Fine aggregate which satisfied the required properties for experimental work and conforms to zone as per the specification of **IS: 383-1970**.

It is purchased from a nearby crusher. The particles meeting the requirements of the specifications with specific gravity 2.54 is used as fine aggregate. The following tests are conducted in accordance with IS standards.

The results of tests on fine aggregate are given in table

Table 4.3 Tests on fine aggregate

1.	Specific gravity	2.54
2.	Fineness modulus	2.636
3.	Water absorption	2.62
4.	Bulk density	
	(i) Loose state	1537.96 Kg/m ³
	(ii) Rodded state	1778.609 Kg/m ³

4.1.3 Polypropylene (PP) Fiber and Carbon Fiber Property

Table 4.4 Shows the properties of the Polypropylene (PP) Fiber and Carbon Fiber.

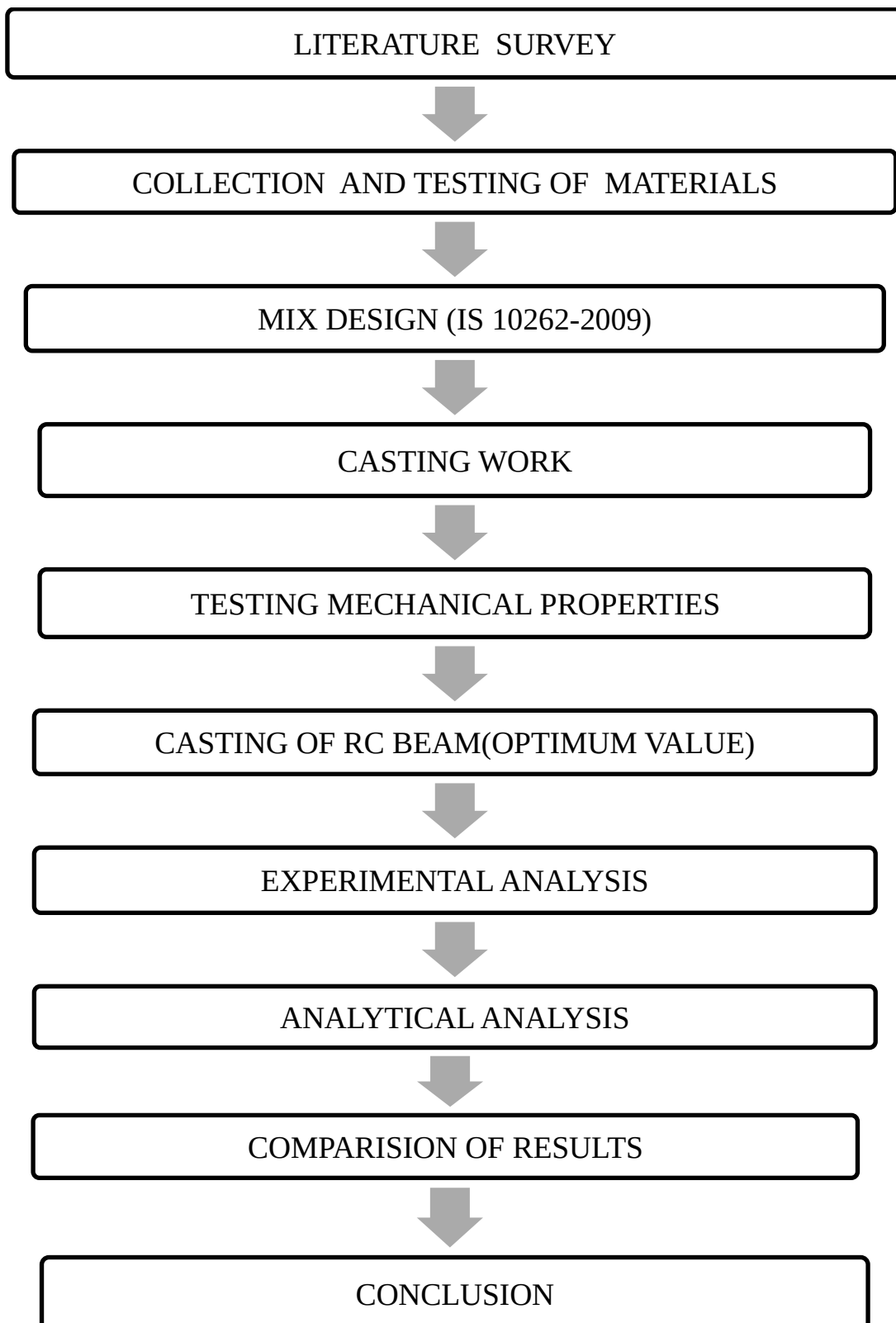
Table.4.4 Polypropylene (PP) Fiber and Carbon Fiber Property

Properties	Polypropylene	<i>Carbon</i>
Density	0.91g/cc	1.65g/cc
Length	12mm	10mm
Diameter	18 microns	7 microns
Aspect ratio	666.67	1428.57

4.1.4 Water

Clean potable water was used for mixing and curing of concrete. Water has been tested and confirms the requirement. Potable water is suitable as mixing water for cement concrete, plain cement concrete for road construction and other applications, since its chemical composition is known and well regulated.

4.2 Methodology



4.3 CONCRETE MIXDESIGN

4.3.1. Mixing Procedure

Uniform mixing of concrete should be ensured to get correct test results of the specimen. For ordinary concrete, initially the coarse aggregate is weighed for required quantity per mix proportioning and poured in mixer; then Sand is weighed and poured into the mixer, which is completely dry.

Cement is weighed and uniformly spread on the surface of sand and uniform mixing is ensured. Dry mixing is carried out, later water mixed with the dry mix, mixing is ensured up to a minimum of 5 minutes until uniform color of concrete is seen. Then concrete is placed in moulds as per procedure.

For fiber Reinforced concrete, the above-explained procedure is followed except that be for adding water to cement, sand and coarse aggregate. polypropylene and carbon fibers are thoroughly mixed with cement, sand and coarse aggregate.

then the mixture of fiber, sand and Cement is mixed with water and further procedure is followed to achieve the different types of fibrous concrete with polypropylene (PP) fiber at 0.5, 1, 1.5,2 and 2.5% volume fractions and carbon fibers at 1, 1.5, 2,2.5 and 3%by addition of fiber over volume of ordinary concrete.

Stipulation for Proportion:

2.1.1 Grade designation =M25

2.1.2 Type of cement = Ordinary Portland Cement 43grade

2.1.3 Max nominal size of the aggregate =20mm

2.1.4 Min Cement content = 300kg/cum

2.1.5 Max W/C ratio =0.5

2.1.6 Exposure condition =Moderate

2.1.7 Type of aggregate = Crushed angular

2.1.8 Aspect Ratio= $l/d = 25/0.5 = 50$

Test Data:

- a) Cement-Portland Cement 43 grade
- b) Specific Gravity of cement =2.7
- c) Specific Gravity of coarse aggregates=2.7
- d) specific Gravity of fine aggregate =2.6
- e) Sand confirming to zone-III

From Sieve Analysis of 1000g of sand:

Table 4.5: Fineness Modulus and Gradation

Size	Wt. retained	Percentage Wt. Retained	Cum. Percentage Wt. retained	Percentage Passing
10	0.00	0.00	0.00	100
4.75	0.00	0.00	0.00	100
2.36	110.5	11.05	11.05	88.95
1.18	129.3	12.93	23.98	76.02
0.6	149.4	14.94	38.92	61.08
0.3	411.2	41.12	80.04	19.96
0.15	199.6	19.96	100	0.00

Fineness Modulus= Cumulative % Wt. Retained/100= 253.99/100= 2.53

When FM is matched with limits of FM for Fine Aggregates, we come to know it is a fine sand. And when Percentage Passing is matched with the data given in IS: 383 for gradation of fine aggregate, we come to know it is of Zone III.

Target mean strength for mix proportion is given by $f_{ck} = f_{ck} + 1.65 \cdot S$
= $25 + 1.65 \cdot 4$ (value is according to IS 10262:2009)
= 31.6 N/mm^2

From Table 2 of IS 10262:2009, to determine the maximum water content. Nominal size of aggregate is 20mm so water content corresponding to it is 186 liters. Estimated water content for 100mm slump is $1.06 \cdot 186 = 197.16$ liter i.e. 197L.

Cement content will be $197 / 0.5 = 394 \text{ Kg/m}^3$.

From Table 5 of IS 456 minimum cement content for moderate exposure condition is $300 \text{ Kg/m}^3 < 394 \text{ Kg/m}^3$.

HENCE OK.

From Table 3 of IS 10262:2009,

Nominal maximum size of aggregate=20 mm

Zone of fine aggregate= Zone III

So,

Volume of Coarse Aggregate per Unit Volume of Total Aggregate= 0.64
Volume of Fine Aggregate per Unit Volume of Total Aggregate= 0.36

4.3.2 Mix Calculation

- a) Volume of concrete = 1m^3
- b) Volume of cement = $\frac{\text{Mass of cement}}{\text{Specific Gravity} \times 1000}$
 $= \frac{394}{2.7 \times 1000} = 0.146 \text{ cu.m}$
- c) Volume of water = $\frac{\text{Mass of water}}{\text{Specific Gravity} \times 1000}$
 $= \frac{197}{1 \times 1000} = 0.197 \text{ cu.m}$
- d) Volume of aggregates = $a - (b + c) = 1 - (0.146 + 0.197) = 0.657 \text{ cu. m}$
- e) Mass of coarse aggregate = $d \times \text{Volume of coarse aggregate} \times \text{Specific gravity of coarse aggregate} \times 1000$
 $= 0.657 \times 0.64 \times 2.7 \times 1000 = 1135.3 \text{ Kg}$
- f) Mass of fine aggregate = $d \times \text{Volume of fine aggregate} \times \text{Specific gravity of fine aggregate} \times 1000$
 $= 0.657 \times 0.36 \times 2.6 \times 1000 = 615 \text{ Kg}$

Cement= 394 Kg/m³
Water= 197 Kg/m³ Fine
Aggregate= 615 Kg
Coarse Aggregate= 1135.3 Kg
W/C ratio= 0.5

Table 4.2: Proportions

Mix Proportion= 1 : 1 : 2

Table 4.7: Amount of material required

PP Fiber Content by Volume (%)	Carbon Fiber Content by Volume (%)	Cement Content (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	PP Fiber (Kg)	Carbon Fiber (Kg)
0%	0%	21.95	21.95	43.918	0	0
0.5%	1.0%	21.95	21.95	43.918	0.23	0.85
1.0%	1.5%	21.95	21.95	43.918	0.44	1.22
1.5%	2.0%	21.95	21.95	43.918	0.68	1.63
2.0%	2.5%	21.95	21.95	43.918	0.90	2.02
2.5%	3.0%	21.95	21.95	43.918	1.12	2.43

4.5 EXPERIMENTAL INVESTIGATION

The experimental investigations carried out on the test specimens to study the strength characteristics of FRC in different combinations. The experiment is conducted on FRC test specimens to ascertain the workability and strength related properties such as cube compressive strength, cylinder split tensile strength and prism flexural strength of various mixes.

Three specimens are tested, and the average is reported for each mix for each test. All the tests are conducted as per Indian standards. Based on the strength test results of cube and cylinders the optimum percentage is arrived. Then the precast concrete panels are casted. After 7,14&28 days curing, the panels are tested for compressive, Tensile and flexural strength.

4.5.1 PREPARATION OF SPECIMEN

The concrete slump test Slump Test (ASTM C 143M-00) is an empirical test that measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of freshly made concrete. Consistency is a term very closely related to workability. It is a term which describes the state of fresh concrete. It refers to the ease with which the concrete flows. It is used to indicate the degree of wetness. Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It is also used to determine consistency between individual batches.

Concrete is prepared as per mix design. The freshly prepared concrete is filled in a clean slump cone in four successive layers. 25 tamping is given for each layer properly before adding another layer. Excessive concrete is strike of with trowel from the top of the mould after the final layer has been tamped. The cone is removed immediately by raising it slowly and carefully in the vertical direction. The settlement or subsidence (slump) (i.e. difference between the height of the slump mould and the highest point of the subsidized concrete cone.) in cone measured as soon as it comes to stop.



Fig.4.1. concrete preparation



Fig.4.2. Slump cone test

Table 4.8 No of specimens casted

MIX	CUBES	CYLINDER	PRISM
MIX 1	9	6	6
MIX 2	9	6	6
MIX 3	9	6	6
MIX 4	9	6	6
MIX 5	9	6	6
ALKALINE TEST	15	-	-
ACID TEST	15	-	-
TOTAL	75	30	30

SHAPE	28 DAYS
BEAM	2(OPTIMUM VALUE)

Table 4.9 Size of specimens casted

SIZE	
CUBE	150*150*150 mm
CYLINDER	150*300 mm
PRISM	100*100*500 mm
BEAM	300*225*1500 mm

4.5.1.1CASTING:

4.5.1.1.1CUBE:

The concrete cube specimens are casted by the consideration of following steps

1. Cube Mould:

The cube Moulds of needed size a 150 x 150 x 150 metric linear unit for nominal size of aggregate not exceptional 38 mm. Cube Moulds shall be supplied with a base plate and they shall be as per IS:10262-2009. Cement= 394 Kg/m³ 27

2. Tamping Rod

As per IS:10262-2009, the tamping rod shall be 16±0.5 mm diameter and 600±2 mm long with a rounded working end and shall be made of mild steel.

3. Casting Process

The cube Mould plates ought to be removed, properly clean assembled and every one the bolts ought to be absolutely tight. A skinny layer of oil then shall be applied on all the faces of the Mould. It's necessary that cube aspect faces should be parallel. After taking concrete samples and combination them, the cubes shall be solid as shortly as possible. The concrete sample shall be crammed into the cube Moulds in layers approximately 5 cm deep. In inserting every scoop

of concrete, the news shall be affected round the prime edge of the Mould because the concrete slides from it, so as to make sure a symmetrical distribution of the concrete with within the Mould. every layer shall be compacted either by hand or by the vibration as delineate below.

4. Compaction by Hand

Each layer of the concrete stuffed within the Mould shall be compacted by not but 35 strokes by tool. The strokes shall be penetrating into the underlying layer and also the bottom layer shall be rodded thought its depth. wherever voids are left by the tool the edges of the Mould shall be approach to shut the voids.



Fig.4.3. Cube Casting

4.5.1.1.2 CYLINDER:

The material properties of concrete can only be properly evaluated if test specimens are made and cured according to standards. Concrete cylinders are typically made to evaluate the compressive strength of the concrete as well as Split tensile strength.

1. Cylinder Mould:

Metal 150 x 300 mm cylinder Moulds are used for casting

concrete test specimens in the field. Before filling, they should be placed on a smooth, firm, level surface.

2. Tamping Rod:

If 150mm diameter Moulds are used then it ought to be stuffed in three equal layers and each layer rodded uniformly twenty-five times with a sixteen millimeter diameter x 450 - 600-millimeter long hemi spherically tipped steel rod.28

3. Casting Process:

The strokes shall be distributed uniformly over the cross-sectional of the Mould. The bottom layer shall be rodded throughout its depth. for every higher layer, the rod shall penetrate regarding 25 mm into the underlying layer. If voids are left by the rod, the edges of the Mould ought to be tapped to shut voids before adding the Ext layer of material.



Fig.4.4. Cylinder Casting

4.5.1.1.3 PRISM:

According to standards Concrete prism are casted to evaluate the flexural strength of the concrete. The casting and testing procedure to be followed as Indian standard code IS 10262-2009.

1. Prism Mould:

The Mould standard size will be 100 x 100 x500 made out of metal. The tamping bar shall be a steel bar weighing 2kg, 40 cm long

and shall have a ramming face 25 mm square. The test specimen shall be made as soon as practicable after Mixing and in such way as to produce full compaction of concrete while neither segregation nor excessive laitance.

2. Casting Process:

The compaction shall be distributed uniformly over the section of the Mould. The bottom layer shall be rodded throughout its depth. For each upper layer, the rod shall penetrate about 25 mm into the underlying layer. If voids are left by the rod, the sides of the Mould should be tapped to close voids before adding the next layer of material.



Fig.4.5. Prism Casting

4.5.1.1.4 RC BEAM:

According to standards Concrete beam are casted to evaluate the flexural strength of the concrete. The casting and testing procedure to be followed as Indian standard code IS 10262-2009.

1. Beam Mould:

The Mould size is 230 x 230 x 1500 made out of wood. The tamping bar shall be a steel bar weighing 2kg, 40 cm long and shall have a ramming face 25 mm square. The test specimen shall be made as soon as practicable after Mixing and in such way as to produce full compaction of concrete while neither segregation nor excessive laitance.

2. Casting Process:

The compaction shall be distributed uniformly over the section of the Mould. The bottom layer shall be rodded throughout its depth. For each upper layer, the rod shall penetrate about 25 mm into the underlying layer. If voids are left by the rod, the sides of the Mould should be tapped to close voids before adding the next layer of material.

3. Reinforcement details:

Main reinforcement = 3 number of 12mm dia bars

Stirrups = 8 mm dia bars @ 150mm c/c

Specimen dimension: 230mmx230mmx1500mm

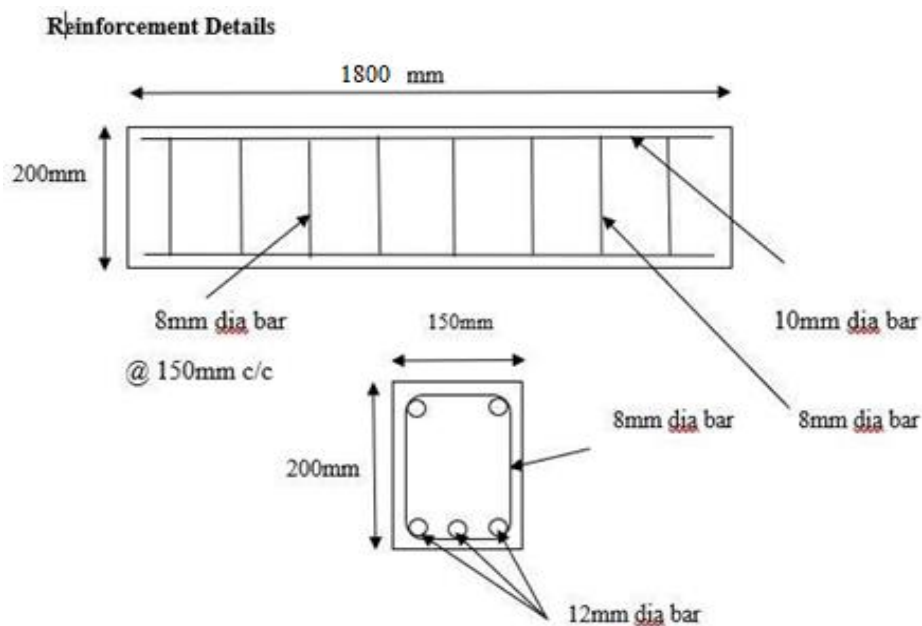




Fig.4.6. Reinforcement Details



Fig.4.7. RC Beam Casting

4.5.1.2 DEMOULDING AND CURING:

DEMOULDING:

Test concrete take a look at specimens ought to be demoulded between sixteen and twenty-four hours when they have been created. If when this area of your time the concrete has not achieved enough strength to modify demoulding while not damaging the specimens then the demoulding should be delayed for an additional twenty-four hours. once removing the concrete specimens from the Mould, take the Mould apart fully. beware to not harm the specimens because, if any cracking is caused, the all-strength parameters could also be reduced. When demoulding, every take a look at concrete specimens ought to be marked with a fair identification on the highest or bottom employing a waterproof crayon or ink. The Mould should be thoroughly clean when demoulding. make sure that grease or dirt doesn't collect between the faces of the flanges, otherwise the 2 halves won't match along properly and there'll be outflow through the joint Associate in Nursing an on an irregular basis formed could result.

CURING:

Curing plays an important role regarding concrete strength development and sturdiness. Curing of Concrete may be a technique by that the concrete is protected against loss of moisture needed for association and unbroken inside the suggested temperature vary. Curing can increase the strength and reduce the Perme ableness of hardened concrete. Curing is additionally helping in mitigating thermal and plastic cracks, which may severely impact durability of structures.

Curing follow involves keeping the concrete damp or wet till the association of concrete is complete and strength is earned. natural process of concrete ought to begin presently after initial setting time of concrete. As per IS 456 – 2000 concrete shouldn't be cured but seven days for standard Portland Cement, and it should be a minimum of ten days for concrete with mineral admixtures or integrated cement are used. just in case of atmospheric condition and extremely dry temperature conditions, the natural process shouldn't be but ten Days for OPC and fourteen days for concrete with integrated cement & mineral admixtures.

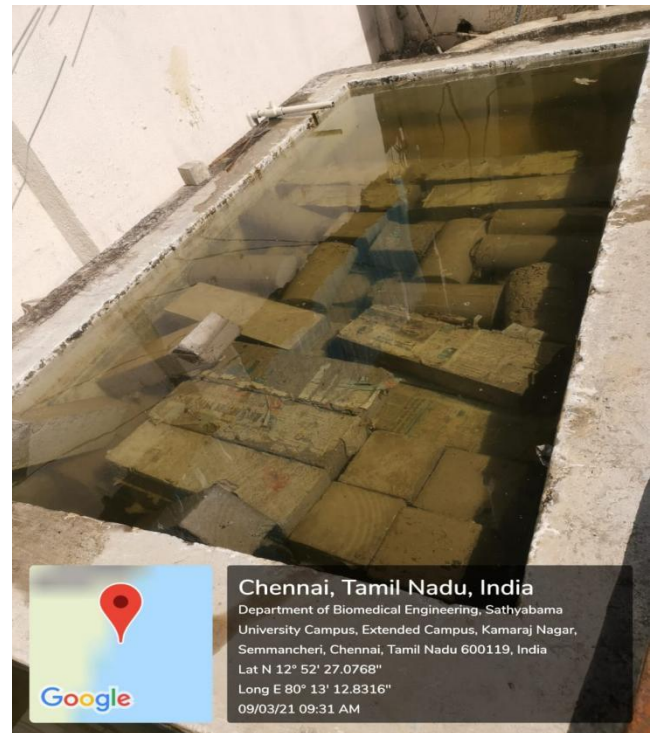
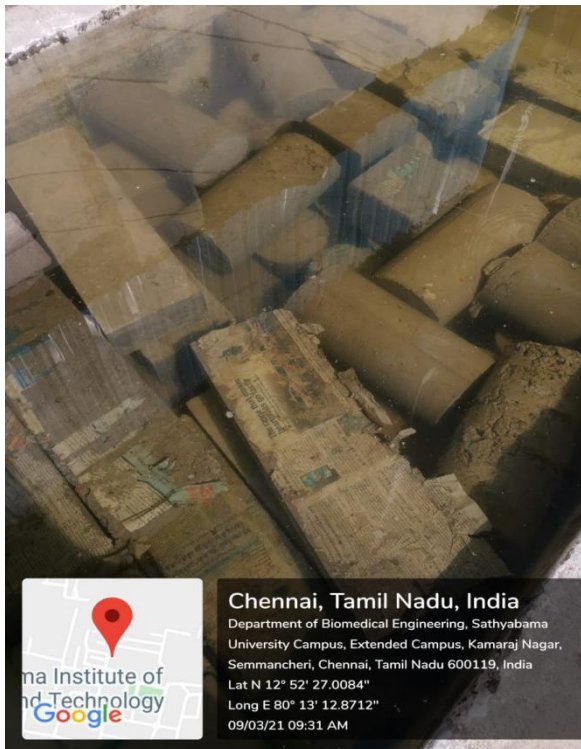


Fig.4.8. Curing

4.5.2.CUBE COMPRESSIVE STRENGTH TEST

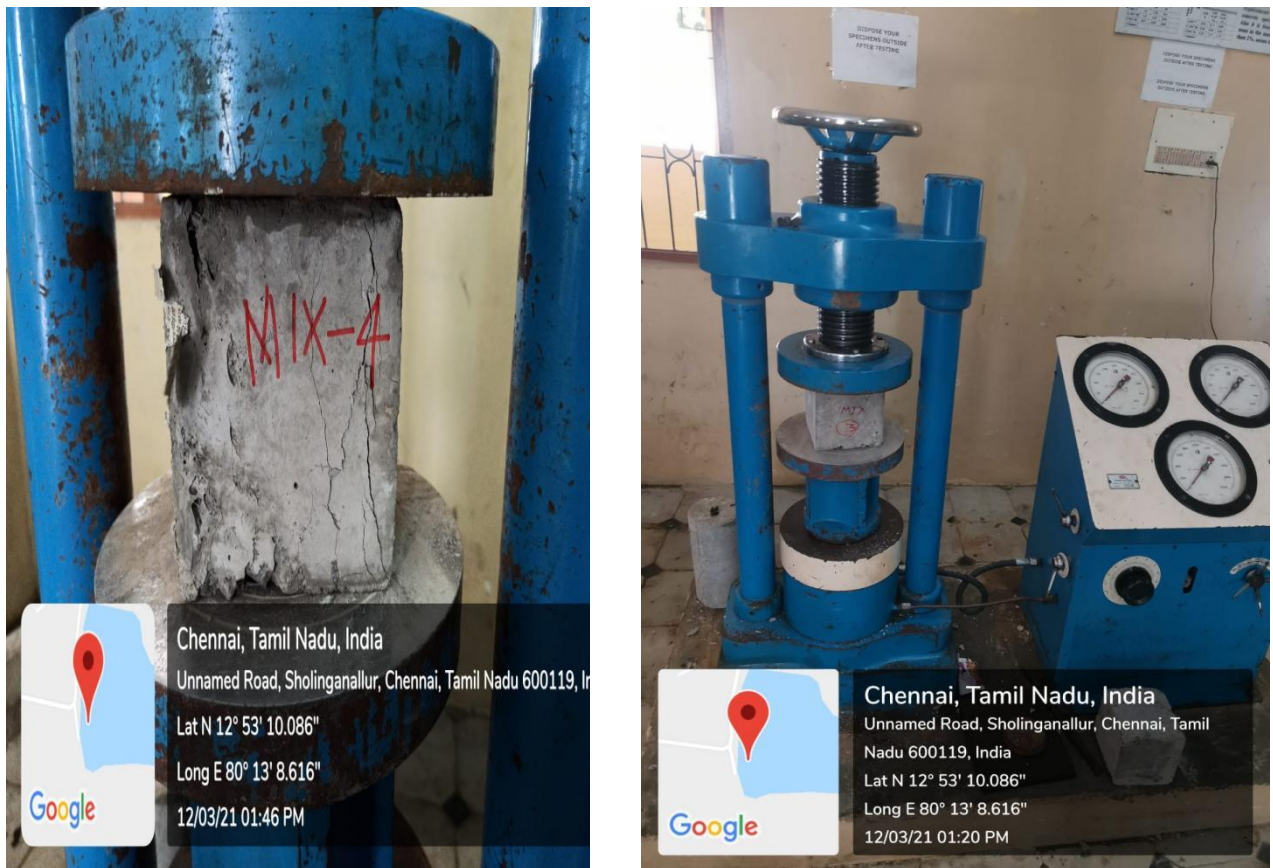


Fig. 4.9 Compressive strength test

The cube compressive strength test is carried out on cube specimens of size 150mm x 150mm x 150mm. All specimens are tested in saturated surface dry condition, after wiping out the surface moisture. For each mix combination, three identical specimens are tested at the age of 7, 14 & 28 days using compression testing machine. Loading was continued till the specimen had failed. The reading at that instant of reversal gives the ultimate load. The test setup is shown in fig. 5.3

4.5.3 CYLINDER SPLIT TENSILE STRENGTH TEST

This is an indirect test to determine the tensile strength of cylindrical specimens. Splitting tensile strength test is carried out at the age of 28 days for the concrete cylinder specimen of size 150mm diameter and 300mm length using universal testing machine. The load is applied gradually till the specimen splits and the readings are noted. The test setup is shown in fig. 5.4. The splitting tensile strength has been estimated using the relationship

$$f = 2P/\pi dl$$

Where, f = Splitting tensile strength of concrete in MPa.

P = Load at failure in Newton

d = Diameter of cylinder = 150mm

l = Length of cylinder = 300mm



Fig. 4.10 Split tensile strength test

4.5.4 FLEXURAL STRENGTH TEST

In order to determine the lateral load resistance, the prisms are tested for flexure. As illustrated in Fig. 5.11. the prism (100mm x 100mm x500mm) were placed horizontally and tested for flexural strength according to third point loading. The initial failure location was observed and found that the failure location of all prism was within the middle third. The third point loading was used to determine the stress at failure.



Fig.4.11 Flexural Strength Test

$$R = \frac{Pl}{bd^2}$$

Where,

R – Bending stress

P – Maximum applied load in N

l – Span length in mm

b – Average width of the specimen in mm

d – Average thickness of the specimen in mm

4.5.5 SPECIMEN DESIGNATION

Table 4.1. shows the details of the tested specimen designation.

Table 4.7 Specimen Designation

PP Fiber Content by Volume (%)	Carbon Fiber Content by Volume (%)	Specimen Designation
0%	0%	Conv
0.5%	1.0%	Mix-1
1.0%	1.5%	Mix-2
1.5%	2.0%	Mix-3
2.0%	2.5%	Mix-4
2.5%	3.0%	Mix-5



4.5.6 RC Beam Test:

A beam with an effective span of 1500 mm are tested under two-point loading by using hydraulic jack with the distance between the loading points as 570 mm after 28 days of curing using wet gunny bags at ambient temperature. LVDT is fixed to measure mid-span deflection.

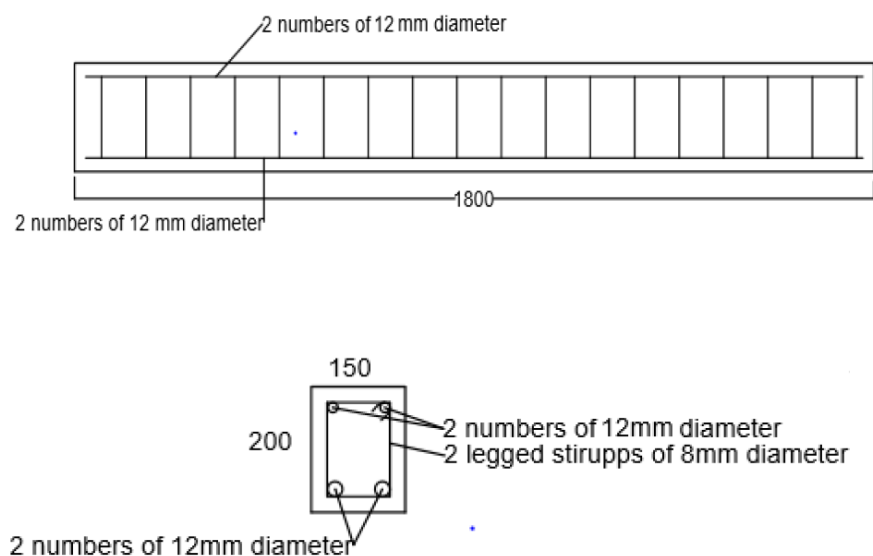


Fig. 5.12 Reinforcement Details



Fig.4.13. Experimental set up for MIX-3 beam



Fig.4.14. Experimental set up for conventional beam

4.6 NUMERICAL ANALYSIS

4.6.1 GENERAL

Today the Finite Element Method (FEM) is considered as one of the well - established and convenient technique for the computer solution of complex problems in different fields of engineering: civil engineering, mechanical engineering, nuclear engineering, biomedical engineering, hydrodynamics, heat conduction, geo-mechanics, etc. From other side, FEM can be examined as a powerful tool for the approximate solution of differential equations describing different physical processes.

This powerful design tool has significantly improved both the standard of engineering designs and the methodology of the design process in many industrial applications the general applicability of the FEM makes it a powerful and universal tool for a wide range of problems. Hence a number of computer program packages have been developed for the solution of a variety of structural and solid mechanics problems.

4.6.2 ANSYS WORKBENCH

The ANSYS Workbench environment is an intuitive up-front finite element analysis tool that is used in conjunction with CAD systems and/or Design Modeler. ANSYS Workbench is a software environment for performing structural, thermal, and electromagnetic analyses. The class focuses on geometry creation and optimization, attaching existing geometry, setting up the finite element model, solving, and reviewing results. The class will describe how to use the code as well as basic finite element simulation concepts and results interpretation.

ANSYS is a general-purpose software, used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers.

ANSYS can import CAD data and also enables to build a geometry with its "preprocessing" abilities. Similarly, in the same pre-processor, finite element model (a.k.a. mesh) which is required for computation is generated. After defining loadings and carrying out analyses, results can be viewed as numerical and graphical.

ANSYS can carry out advanced engineering analyses quickly, safely and practically by its variety of contact algorithms, time based loading features and

nonlinear material models.

ANSYS Workbench is a platform which integrates simulation technologies and parametric CAD systems with unique automation and performance. The power of ANSYS Workbench comes from ANSYS solver algorithms with years of experience. Furthermore, the object of ANSYS Workbench is verification and improving of the product in virtual environment.

4.6.3 ANSYS MODEL

The analysis focuses on

1. Engineering data
2. Fixing up the geometry of beam in design modeler
3. Setting up the finite element model
4. Providing the support and loading conditions
5. Checking for equivalent stress, strain and deformation

4.6.3.1 ENGINEERING DATA

The materials are to be assigned for the creating model. Here selecting the materials which are used in modeling like steel, concrete. The grade of concrete used in this modeling is Mix-3 Compressive strength value. and grade of steel is FE415. For reinforcement details refer fig 5.2.

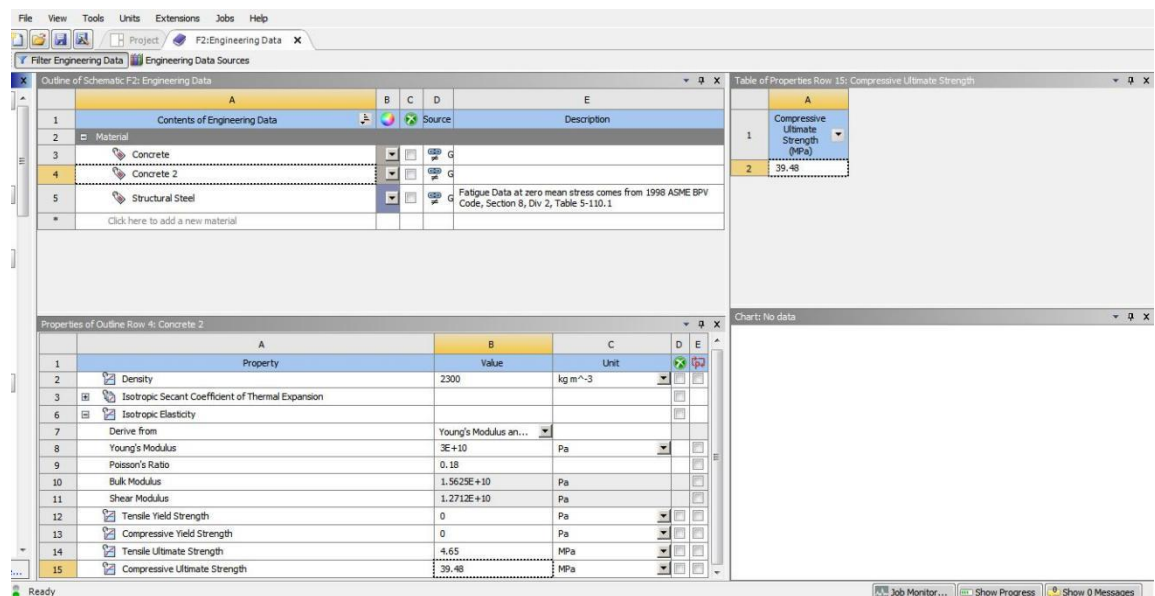


Fig 4.14 ANSYS Material Property

4.6.3.2 GEOMETRY CREATION

After assigning the material in engineering data, the model is created by providing the proper dimensions of the beam, diameter of bars. Separate model is to be created for all the materials like concrete, steel and it should be assigned for the respective model.

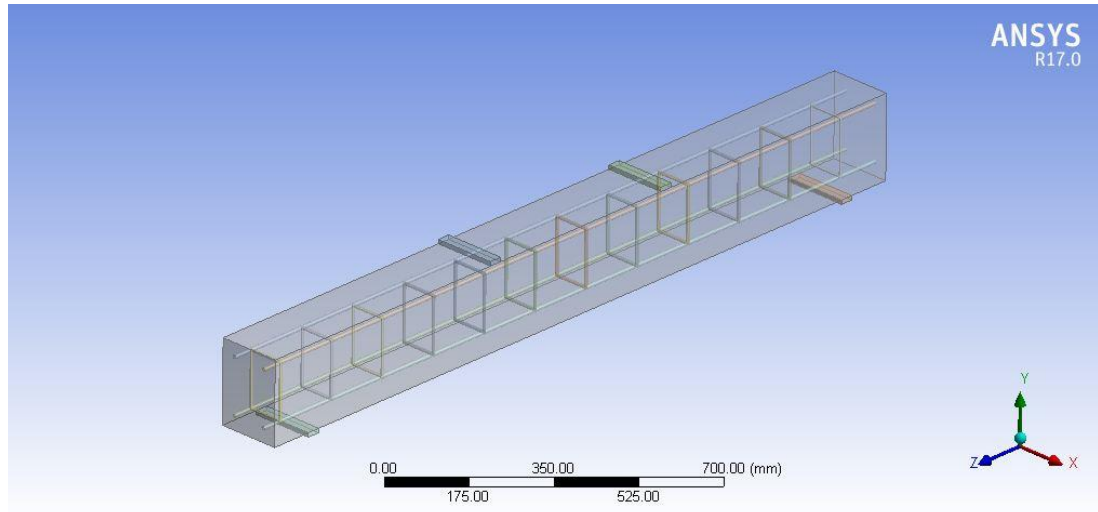


Fig 4.15 geometry of beam in design modeler

4.6.3.3 SETTING UP THE FINITE ELEMENT MODEL

After completing the geometry design, go to the modeling phase and assign all the material properties. Then we will generate mesh which helps us in solving the model in finite element method and results can be obtained accurately.

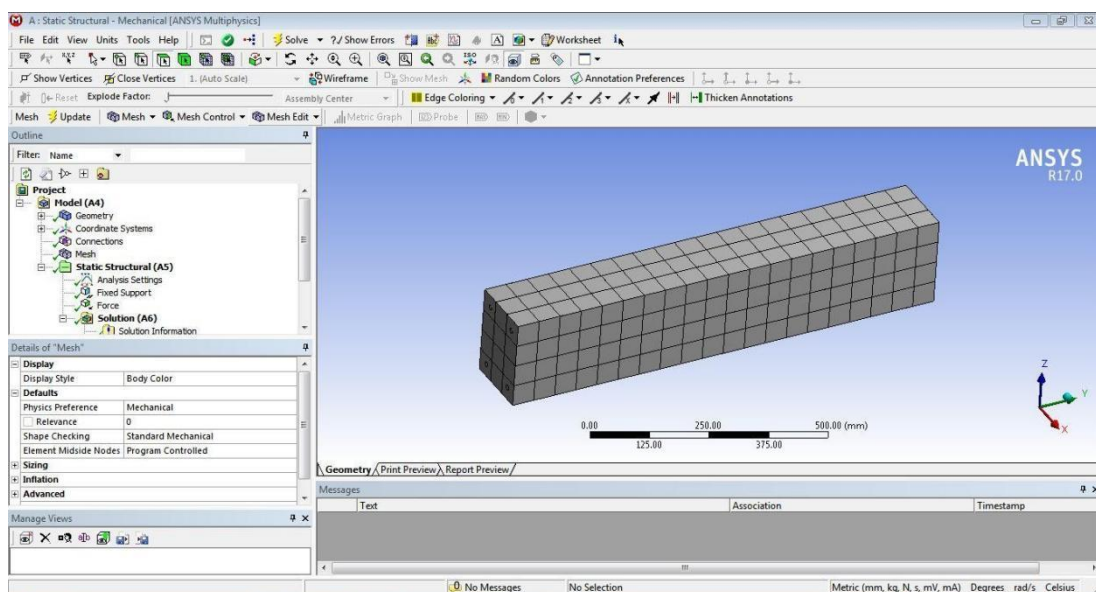


Fig 4.16 mesh in mechanical model

4.6.3.4 PROVIDING THE SUPPORT AND LOADING CONDITION

The RC beam were applied two-point load After the application of load the model is solved for the required results and the failure mode of the model is obtained.

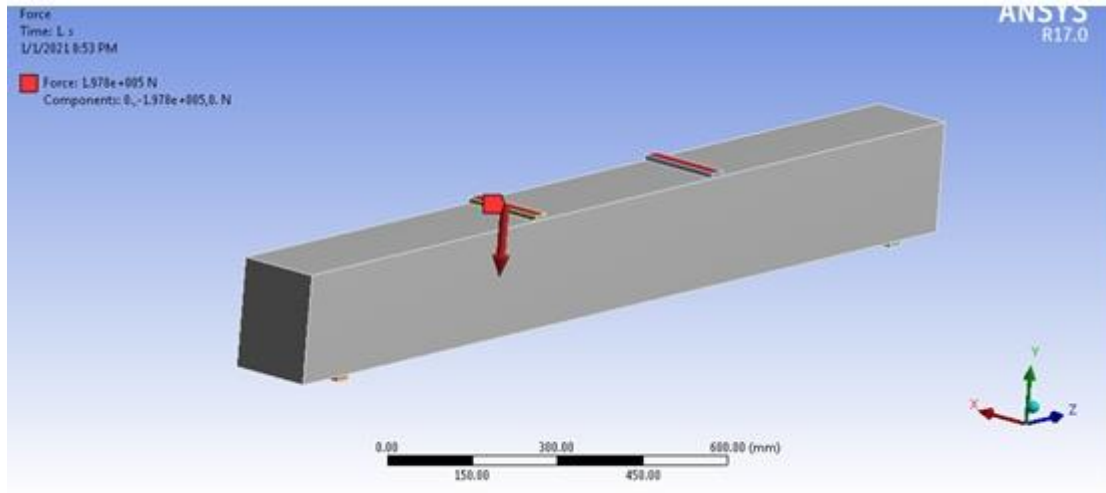


Fig4.17 Loading condition

CHAPTER-5

RESULT AND DISCUSSION

This chapter deals with the presentation of test result, and discussion on compressive strength, tensile strength and flexural strength development of fiber reinforced concrete over ordinary concrete at different percentage and different curing period.

5.1 Slump Cone Test Result

Table 5.1 Slump Value

Specimen	Slump Result
Conv	100 mm
Mix-1	49 mm
Mix-2	100 mm
Mix-3	48 mm
Mix-4	44 mm
Mix-5	50 mm

The workability of concrete on Conv,Mix-3,Mix-4 and Mix-5 was is lower since carbon fiber has a low moisture absorption.

5.2 Experimental Results:

5.2.1Compressive strength

This procedure is applicable for establishing testing technique for the compressive strength of concrete specimens. Specimens hold on in water shall be tested like a shot on removal from the water and whereas they're still within the wet condition. Wet condition is also maintained by covering the specimens with wet gunny. The bearing surfaces of the testing machine shall be cleaned and dry loose sand or alternative material far away from the surfaces of the specimen that area unit to be in contact with the compression platens. just in case of the cubes,

37 the specimen is placed in the machine in such a fashion that the load shall be applied to opposite sides of the cubes as forged that's, to not the highest and bottom.

The axis of the specimen shall be carefully aligned with the middle of thrust of the spherically seated platen. No packing shall be use between the faces of the check specimen and therefore the steel platen of the testing machine. The loading rate shall be set to five.2 KN/sec for fifteen cm cube, to uniformly load the specimen.

The load shall be applied while not shock, and raised incessantly till the resistance of the specimen to the increasing load breaks down and no bigger load will be sustained. The utmost load applied to the specimen shall then be recorded and therefore the appearance of the concrete and any uncommon options within the style of failure shall be noted.

The compressive strength is the main criterion for the purpose of structural design. The strength development in fiber reinforced concrete studied at 7,14 &28days.Thevariationof compressive strength with different percentage of fiber over normal concrete. Result of all concrete specimens exhibited increase in compressive strength with increase of curing age.

Table 5.2: 7 Day Compressive Strength

% FIBER	Load in KN	COMPRESSIVE STRENGTH in N/mm²
Conv	474.6	21.093
Mix-1	510.8	22.702
Mix-2	521.2	23.170
Mix-3	541.4	24.062
Mix-4	528.1	23.471
Mix-5	502.7	22.342

$$\begin{aligned}
 \text{7 Day Compressive Strength} &= \text{Load/Area} \\
 &= 474.6 \times 1000 / (150 \times 150) \\
 &= 21.093 \text{ N/mm}^2
 \end{aligned}$$

% FIBER	Load in KN	COMPRESSIVE STRENGTH in N/mm²
Conv	572.43	25.441
Mix-1	664.97	29.56
Mix-2	686.25	30.50
Mix-3	710.72	31.58
Mix-4	628.96	27.95
Mix-5	594.40	26.46

Table 5.3: 14 Day Compressive Strength

Table 5.4: 28 Day Compressive Strength

% FIBER	Load in KN	COMPRESSIVE STRENGTH in N/mm²
Conv	715.54	31.80
Mix-1	831.22	36.94
Mix-2	859.50	38.20
Mix-3	888.40	39.48
Mix-4	786.20	34.94
Mix-5	744.26	32.07

Table 5.2: 7 Day Compressive Strength

% Fiber	7 Days N/mm ²	14 Days N/mm ²	28 Days N/mm ²
Conv	21.093	25.441	31.80
Mix-1	22.702	29.55	36.94
Mix-2	23.170	30.5	38.20
Mix-3	26.062	31.58	42.4
Mix-4	23.471	27.95	34.94
Mix-5	22.342	26.46	32.05

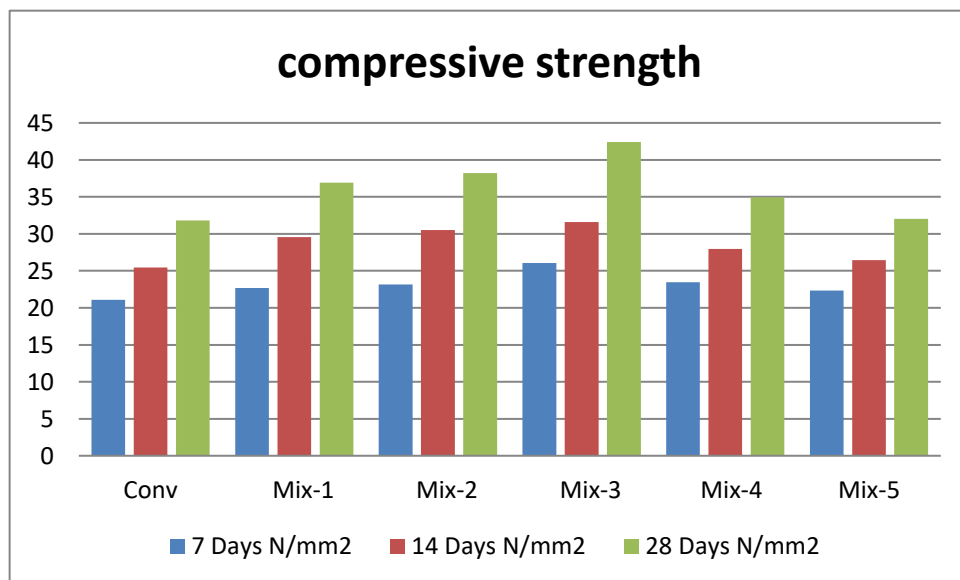


Fig5.1: Comparison of compressive strength

Fibers do enhance the static compressive strength of concrete, with increases in strength ranging from essentially nil to perhaps 24%. Even in members which contain conventional reinforcement in addition to the fibers, the fibers have little effect on compressive strength. However, the fibers do

substantially increase the post-cracking ductility, or energy absorption of the material

5.2.2 Split Tensile Strength

This procedure is applicable for establishing testing methodology for the split durability of concrete specimens. Specimen once received dry shall be unbroken in water for twenty-four hours before they're taken for testing. Unless different conditions square measure needed for specific laboratory investigation specimen shall be tested at once on removal from the water while they're still wet. Surface water and grit shall be wiped off the specimens and any sticking fins far from the surfaces that square measure to be involved with the packing strips.

Marking - diametric lines shall be drawn on the 2 ends of the specimen victimisation any appropriate procedure and device which will make sure that they're within the same axial plane. putting of the specimen within the Testing Machine- The bearing surfaces of the testing machine and of the packing strips shall be cleaned.

Positioning – one amongst the laminate strips shall be cantered on the middle of the lower platen. The specimen shall be placed on the laminate strip and aligned so the lines marked on the ends of the specimen square measure vertical and focused over the laminate strip. The second laminate strip shall be placed lengthwise on the cylinder, focused on the lines marked on the ends of the cylinder. The assembly shall be portioned to make sure the subsequent conditions:

- The lines marked on the ends of the specimen square measure vertical which the projection of the plane of the 2 lines marked on the ends of the specimen intersects the middle of the platens.
- The supplementary bearing bar or plate, when used, and also the center of the specimen square measure directly at a lower place the middle of thrust of the spherical bearing block.

Rate of Loading – The load shall be applied while not shock and inflated unceasingly at a rate to supply around a ripping tensile stress of roughly fourteen to twenty one kg/cm²/min till the resistance of the specimen to the increasing load breaks down and no larger load will be sustained. This rate of loading for fifteen 39 cm diameter and thirty cm length cylinder works out 1.62

kN/sec to 2.43 kN/sec. the most load applied to the specimen shall then be recorded. the looks of concrete and any uncommon options within the sort of failure shall even be noted.

The splitting tensile strength was determined at ages of 7 ,14& 28 days for moist cured concrete specimens. The test result of the splitting tensile strength is indicated that in general, all types of concrete specimens exhibited continued increase in splitting strength with development of curing ages.

From graphs it is observed that the splitting tensile strength of fiber reinforced concrete increases at all ages of curing compared with the ordinary concrete. This increase maybe ascribed to the significant reduction in capillary porosity of the cement matrix as well as a good dispersion of the cement grains throughout the mix, there by increasing bond strength leading to a significant increase in splitting tensile strength.

Table 5.6: 7 Day Split Tensile Strength

% FIBER	Load in KN	TENSILE STRENGTH IN N/mm²
Conv	224.5	3.17
Mix-1	241.2	3.41
Mix-2	248.6	3.52
Mix-3	269.5	3.81
Mix-4	298.6	4.22
Mix-5	311.4	4.04

$$\begin{aligned}
 \text{7 Day Tensile Strength} &= 2P/\pi DL \\
 &= 2*224.5*1000/\pi*150*300 \\
 &= 3.176 \text{ N/mm}^2
 \end{aligned}$$

% FIBER	Load in KN	TENSILE STRENGTH IN N/mm²
Conv	237.7	3.36
Mix-1	245.0	3.46
Mix-2	260.7	3.69
Mix-3	279.5	4.56
Mix-4	319.23	4.51
Mix-5	348.48	4.40

Table 7.7: 14 Day Split Tensile Strength

Table 5.8: 28th Day Split Tensile Strength

% FIBER	Load in KN	TENSILE STRENGTH IN N/mm²
Conv	297.2	4.21
Mix-1	306.3	4.34
Mix-2	313.7	4.44
Mix-3	328.6	5.65
Mix-4	361.2	5.11
Mix-5	381.2	5.03

Table 5.9 7,14 &28 days Split Tensile Strength

% Fiber	7 Days N/mm ²	14 Days N/mm ²	28 Days N/mm ²
Conv	3.17	3.36	4.21
Mix-1	3.41	3.46	4.34
Mix-2	3.52	3.69	4.44
Mix-3	3.81	4.56	5.65
Mix-4	4.22	4.51	5.11
Mix-5	4.05	4.41	5.03

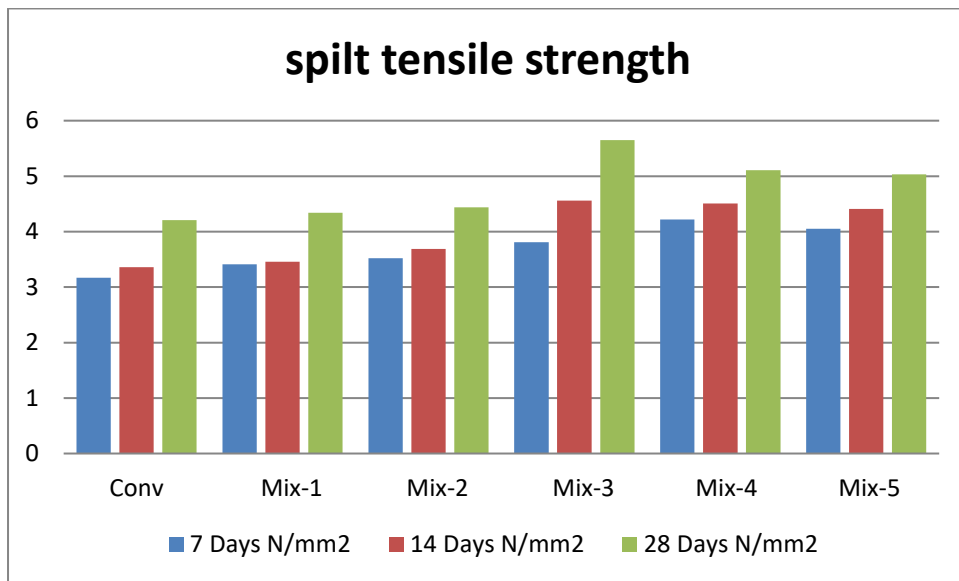


Fig5.10: 7,14 &28Day Split Tensile Strength

Fibers aligned in the direction of the tensile stress may bring about very large increases indirect tensile strength, as high as 28% for straight fibers. However, for more or less randomly distributed fibers, the increase in strength is much smaller, ranging from as little as no increase in some instances to perhaps 40%, with many investigations indicating intermediate values. Splitting-tension test of FRC show similar result. However, as in compression, fibers do lead to major increases in the post-cracking behavior or toughness of the composites.

5.2.3 Flexural Strength

It is seen that strength of concrete in compression and tension in both direction (i.e. direct tension and flexural tension) are closely related, but the relationship is not of direct proportionality. The ratio of two strengths depends on general level of strength of concrete. In other words, for higher compressive strength of concretes hows higher tensile strength, but the rate of increase of tensile strength is increasing order.

Table 5.10: 7 Day Flexural Strength

% FIBER	Load in KN	TENSILE STRENGTH IN N/mm ²
Conv	14.5	5.80
Mix-1	15.2	6.08
Mix-2	15.6	6.23
Mix-3	16.4	7.56
Mix-4	16.9	6.76
Mix-5	19.5	7.8

$$\begin{aligned}\text{7 Day Flexural Strength} &= PL/BD^2 \\ &= 14.5 \times 400 \times 1000 / 100 \times 100^2 \\ &= 5.8 \text{ N/mm}^2\end{aligned}$$

Table 5.11: 14 Day Flexural Strength

% FIBER	Load in KN	TENSILE STRENGTH IN N/mm²
Conv	16.02	6.40
Mix-1	16.65	6.66
Mix-2	17.05	6.82
Mix-3	17.55	8.02
Mix-4	17.91	7.16
Mix-5	21.15	7.26

Table 5.12: 28th Day Flexural Strength

% FIBER	Load in KN	TENSILE STRENGTH IN N/mm²
Conv	17.8	7.12
Mix-1	18.5	7.40
Mix-2	19.0	7.61
Mix-3	19.5	9.82
Mix-4	19.9	8.45
Mix-5	23.5	8.00

Table 5.13 :7,14 &28 days Flexural Strength

% Fiber	7 Days N/mm ²	21 Days N/mm ²	28 Days N/mm ²
Conv	5.80	6.40	7.12
Mix-1	6.08	6.66	7.40
Mix-2	6.23	6.82	7.61
Mix-3	7.56	8.02	9.82
Mix-4	6.76	7.16	8.45
Mix-5	7.8	7.26	8.00

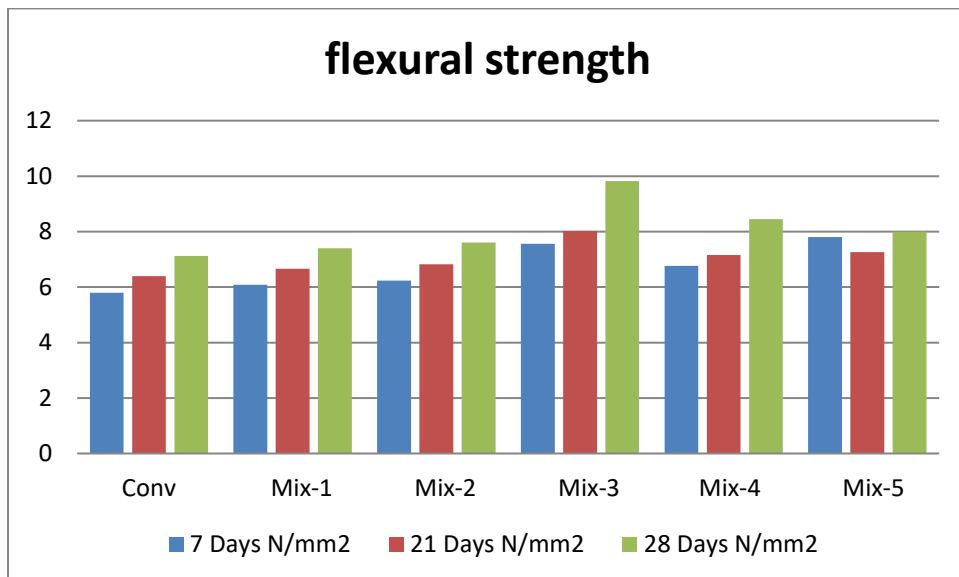


Fig 5.3 : 7, 14 &28 Day Flexural Strength

Fibers are generally found to have aggregate much greater effect on the flexural strength of FRC than on either the compressive or tensile strength, with increases of more than 33.14% having been reported. The increases in flexural strength is particularly sensitive, not only to the fiber volume, but also to the aspect ratio of the fibers, with higher aspect ratio leading to larger strength increases. For all of the empirical measures of toughness, fibers with better bond characteristics (i.e. deformed fibers, or fibers with greater aspect ratio) give higher toughness values than do smooth, straight fibers at the same volume concentrations.

Table 5.14: Percentage Increase in Strength over conventional mix

Sl. No	Properties	Gain Over Normal Concrete
1.	Compressive Strength	+24.15%
2.	Split Tensile Strength	+28.02%
3.	Flexural Strength	+33.14%

5.2.4 RC Beam Test Result:

The beam was subjected to two-point loading after 28 days of curing. Three LVDTs were placed below the two-point loading supports and mid-point. For every 10 kN, three deflection values were noted. The first crack load for the MIX-3 beam was 90.5 kN and the first crack load for the Conventional beam was observed to be 65.5kN.

Specimen details:

Main reinforcement = 3 number of 12mm dia bars

Stirrups = 8 mm dia bars @ 150mm c/c

Specimen dimension= 150mmx200mmx1000mm

Table 5.15 load and deflection values (experimental)

Load(KN)	CONV	MIX-3
10	40	45
20	43.5	101
30	56	124
40	70	159
50	80	212.5
60	106	284
70	132	307.5
80	159	362
90	214.5	388
100	237	402.5
110	261	434.5
120	286.5	478
130	333	518
140	371	570.5
150	418	625
160	380	710.5
170	348	754.2
180		793
190		826
200		880
210		905
220		775
230		748

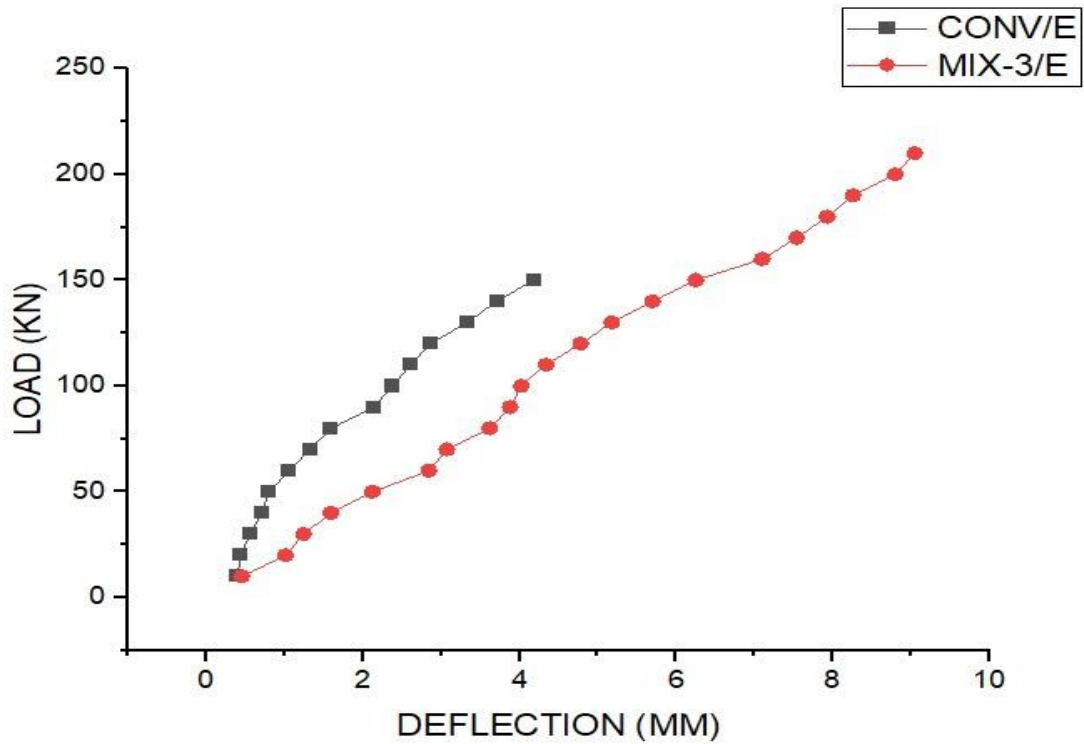


Fig.5.4 load and deflection behavior (experimental)

5.3 Numerical Result:

5.3.1 Conventional beam:

The numerical analysis is conducted for the Conventional beam. the stress contour of conventional RC beam are shown in Fig.7.4. It is observed that the beams.

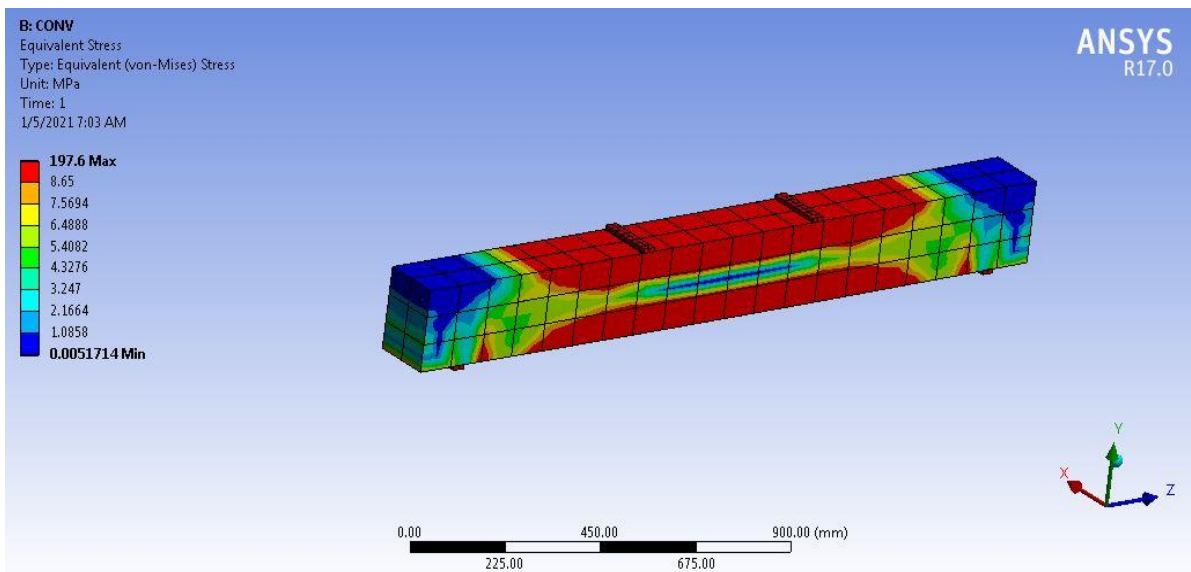


Fig 5.4 Stress Contour for RC Beam

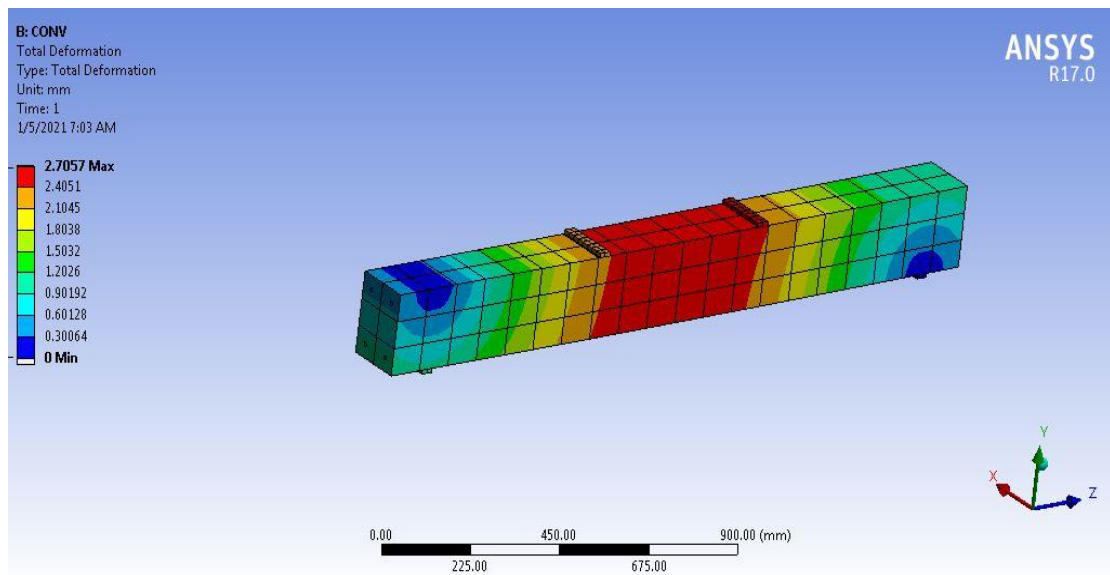


Fig 5.5 Deformation for RC Beam

5.3.2 MIX-3:

The numerical analysis is conducted for the Mix-3. the stress contour of Mix-3RC beam are shown in Fig.5.6. It is observed that the beams.

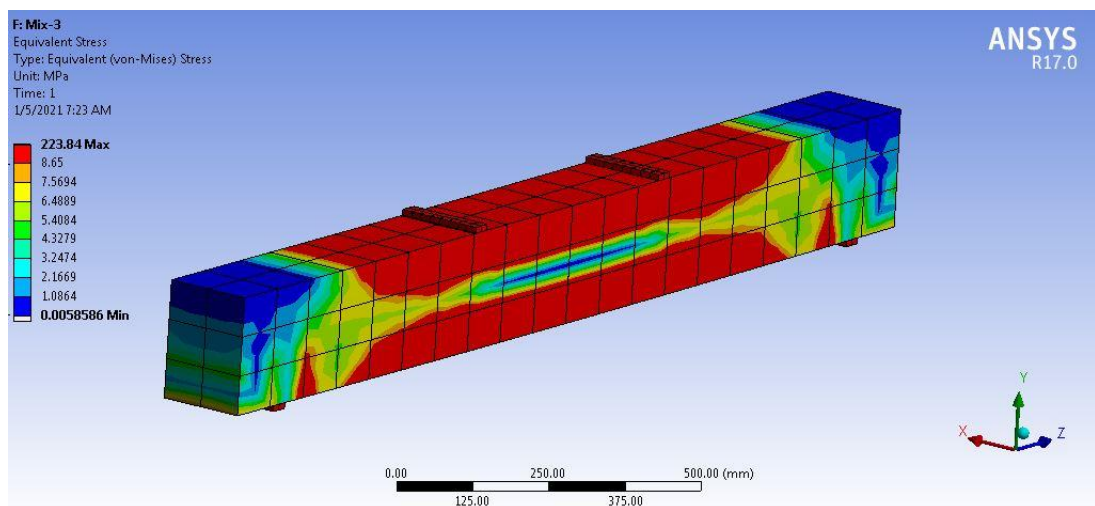


Fig 5.6 Stress Contour for Mix-3 Beam

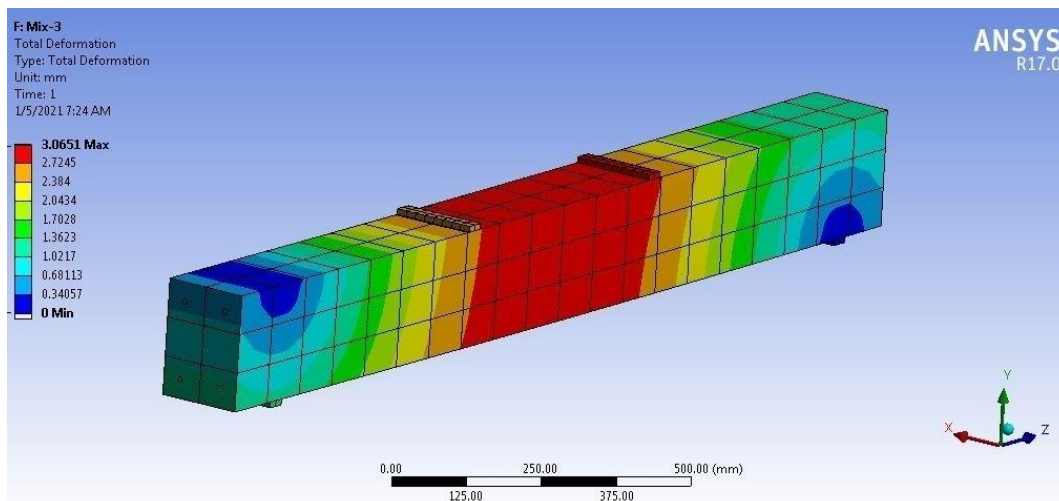


Fig5.7 Deformation for Mix-3 Beam

Table 5.16 load and deflection value (analytical)

SN. No	Specimen Designation	Ultimate Load (KN)	Deflection (mm)
1	Conventional Beam	75	3.3
2	MIX-3	170	6.6

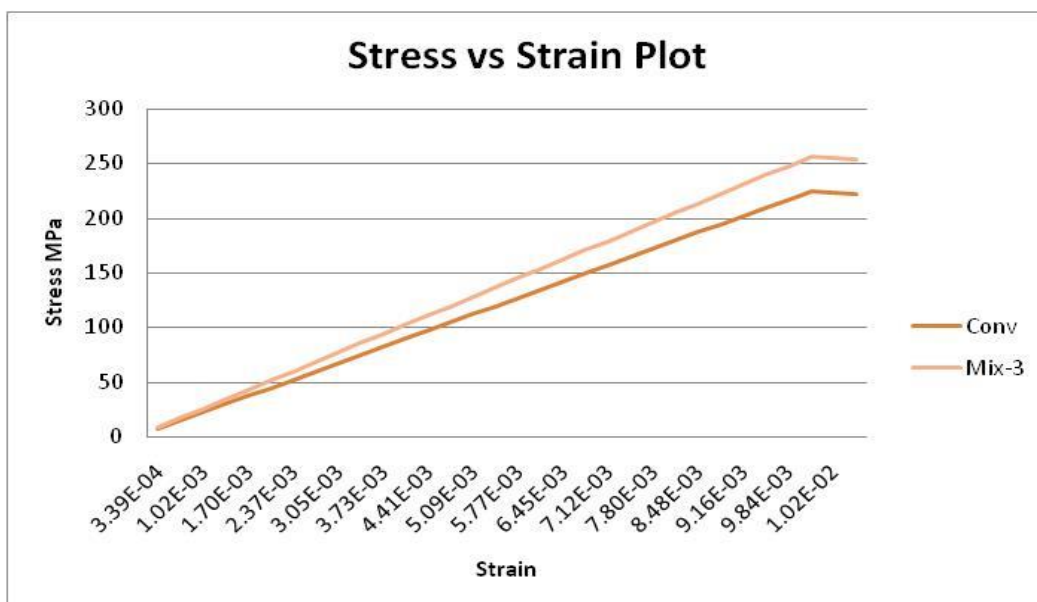


Figure 5.8 stress vs strain curve

The evolved solution will be done using the finite element method and this is the results for maximum deformation is shown in fig 5.8.

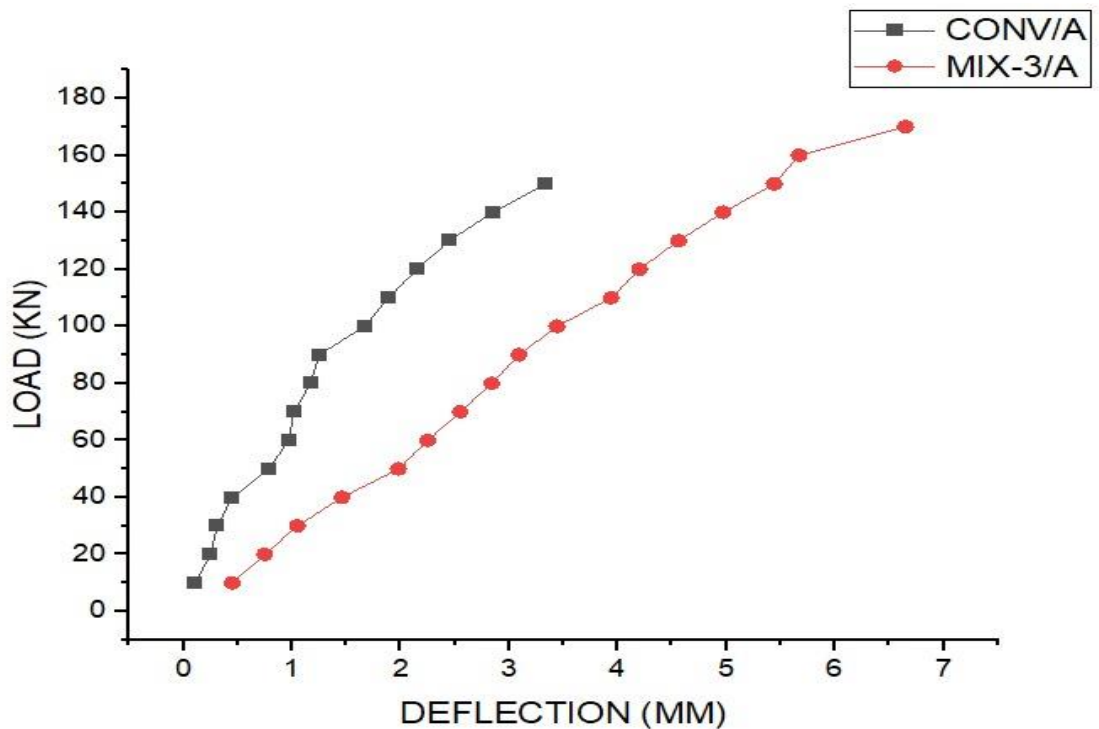


Fig5.9 load vs deflection curve (analytical)

The load vs deflection curve and stress vs strain curve for analytical study is plotted in below fig 7.6 and 7.7. This curve is plotted by the results obtained in ansys software. And it is compared with experiment results.

5.4 COMPARISON OF EXPERIMENTAL RESULTS WITH ANALYTICAL RESULTS:

We could see that almost the experimental value of conventional beam values are almost same for both analytical and experiment procedures. But where as we see the MIX-3 it shows some slight variations in analytical value. The experiment value is higher than the analytical value. So the experimental procedure shows us that it can used to achieve high strength with minimum increase of whole weight of the concrete.

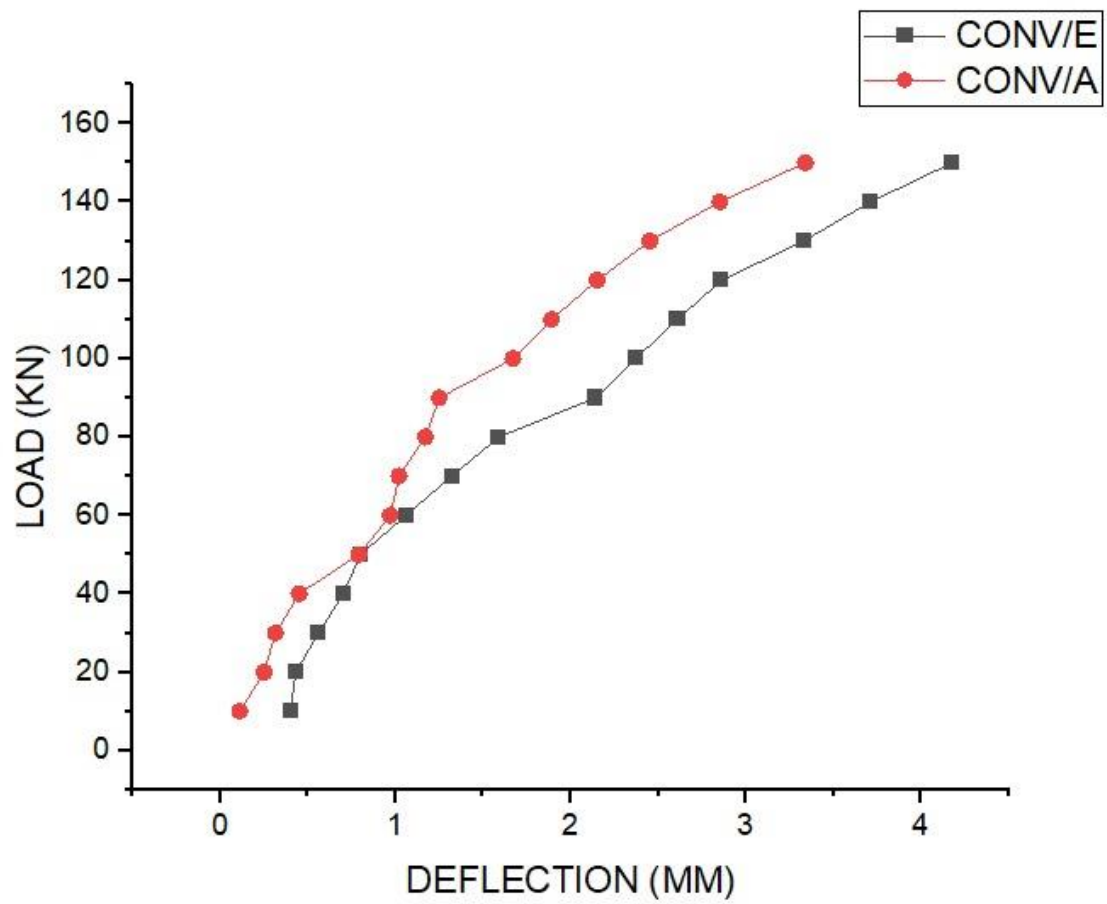


Fig 5.10 comparison of conventional beam experimental results with analytical results

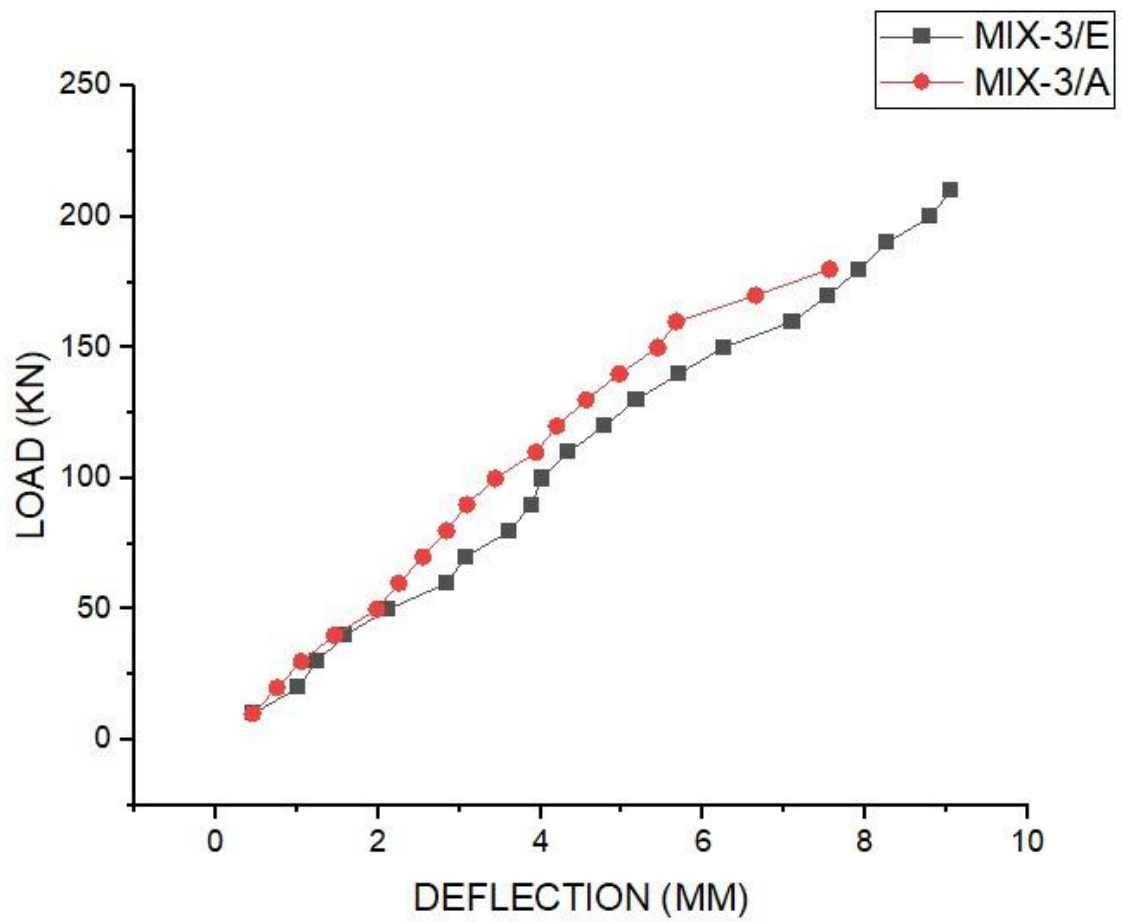


Fig5.11comparison of MIX-3 beam experimental results with analytical results

CHAPTER-6

CONCLUSION

As we could conclude that the MIX-3 is the optimum mix to achieve the ultimate strength when we compare it with other mixes. Since it shows the highest performance in all types of test made when compared to the conventional concrete. The addition of fibers effect on the compressive strength has increasing by 24.15% with (Mix-3) of fiber than start increasing and then decreases by with increase the fiber quantities.

The increase in polypropylene fiber showed an increase in compressive strength to the normal mix. The results of the splitting tensile strength tests show that, there is a increase in strength by increasing fiber. it was found that highest splitting tensile strength was achieved by Mix-3 of fibers, which was found about 5.39 N/mm² compared with other mix.

The load carrying capacity is increased to 28.02 % compared with the conventional specimen. Based on the experimental test result there is an improvement in Flexural strength of the Mix-3 mix is higher at age of 7, 14 & 28 days respectively compared to all other mixes. High quantities of fiber produced concrete with poor workability and segregation, higher entrapped air and lower unit weight.

The beams were analyzed using 2-point load test and flexural cracks has been observed. From the study it shows that use of CFRP showed an improvement in both the ways and also increase the flexural capacity of the beam and it helps to increase stiffness under service loads. It also helps to reduce the deflection in both ways.

Resistance to change though how ever small disturbs our society, hence we are always reluctant to accept even the best. Its high time that we overcome the resistance and reach for the peaks. FRC opens a new hope to developing and globalizing the quality and reshaping the face of the “True Indian Structures”.

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